EXPERIMENTS

AND

OBSERVATIONS

RELATING TO

ACETOUS ACID, FIXABLE AIR, DENSE IN-
FLAMMABLE AIR, OILS, AND FUEL; THE
MATTER OF FIRE AND LIGHT, METALLIC
REDUCTION, COMBUSTION, FERMENTA-
TION, PUTREFACTION, RESPIRATION,

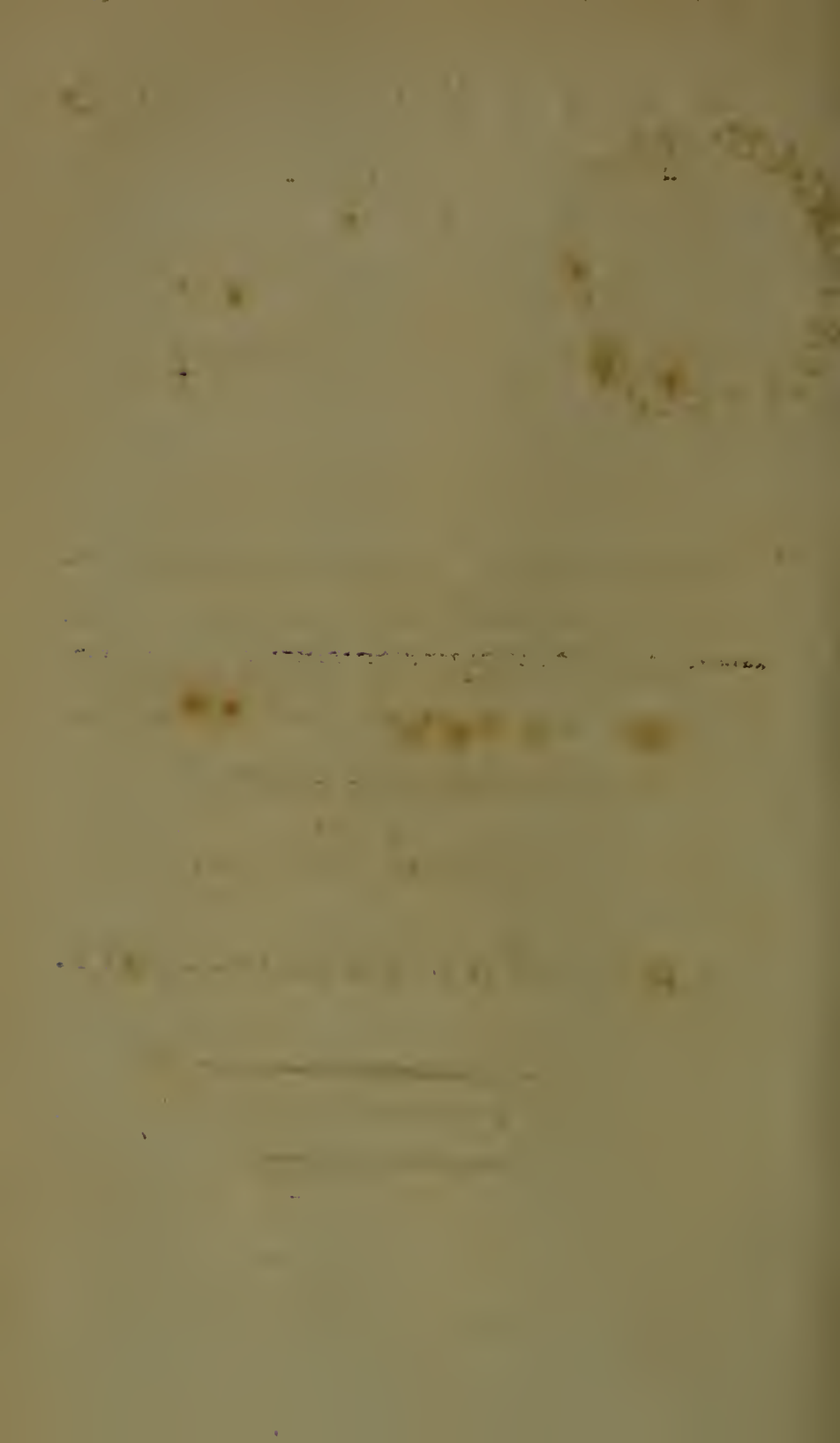### AND OTHER SUBJECTS OF

CHEMICAL PHILOSOPHY.

BY BRYAN HIGGINS, M. D.

Under the animating, and FRIENDLY PATRONAGE

Of the MUNIFICENT and MOST NOBLE

HUGH late DUKE of NORTHUMBERLAND

This Volume was commenced and concluded :

To HIM it was to be prefented,

The PLEDGE of better Efforts

In his favourite Science :

And NOW

TO HIS EVER HONOURED MEMORY,

It is gratefully and pioufly infcribed,

By BRYAN HIGGINS.

A 3

THE
PREFACE

HAVING announced this work
to many of my friends in the
beginning of the laſt year, when
more than a third of it was printed,
I think it incumbent on me to re-
late the circumſtances which have
delayed the publication of it to this
time.

From the beginning of March to
the end of July laſt, all the time
that I could ſpare from the daily

duties of my profeffion, was fully
employed with private pupils in pre-
paring for the enfuing Courfe of
Chemiftry, and in forwarding their
refpective purfuits, and afterwards
in the inceffant bufinefs of the ex-
periments and operations exhibited
in that Courfe.   During this time
it was impoffible for me to revife
the proof-fheets with the requifite
attention, and the printing was ne-
ceffarily fufpended.

In the public propofals for the
Courfe, which commenced in April,
the following article appeared :---
3dly. "*That it fhall exhibit the im-
portant advances lately made in the
knowledge of air and other elaftic
fluids, of the vegetable acid, phlo-
gifton, fire, and Light.*"

In confequence of this decla-
ration, I introduced in the Courfe,
all that was new in the experiments,
or interefting in the doctrines of this
volume; and infifted particularly
on the circumftances that gave
rife to the controverfy which was
fo ably and politely maintained, in
the Philofophical Tranfactions, by
Mr. Cavendifh and Mr. Kirwan, con-
cerning the principles of fixable air.

By this communication to a very
refpectable and fcientific audience,
I deprived the intended work of
every advantage of novelty; and
having gratified the curiofity of
thofe to whom it was announced, I
felt no greater folicitude about the
fpeedy publication of it, than was
confiftent with my health, and with
engage-

engagements which admitted no
procraftination.

During a part of the laft fum-
mer, I was totally difabled by fick-
nefs; and for fix months afterwards,
all the time that I could fpare, was
employed in experiments for the
perfection of glafs for optical ufe,
which I profecuted with extraor-
dinary affiduity becaufe my vene-
rated patron the late Duke of Nor-
thumberland expreffed fome wifhes
to this effect, and in enquiries
highly interefting to artifts who
were impatient of delay.

The printing, therefore, was not
refumed until laft March; fincewhich
time, fome unexpected delays were
made at the prefs, andlately the pub-
lication was deferred on account of
the

the impending lamentable lofs already expreffed.

Thofe who confider that my profeffion will not permit any feclufion from fociety, or retirement from interruption, and that in the moments occafionally fnatched from thefe numerous avocations, the moft verfatile mind cannot apply to a work of this kind, with all the vigour which it might acquire by deliberation or reft; will rather wonder at my attempting to publifh a volume, than at the delay, the numerous uncorrected errors of the prefs and of the author, and that exceffive brevity, which requires greater attention in the perufal of many of the following fections, than readers are ufed to beftow on temporary publications.

THE

CONTENTS.

SEC-

SECTION XIV.

SECTION XV.

SECTION XVI.

SECTION XVII.

SECTION XVIII.

SECTION XIX.

S E C T I O N   XX.

S E C T I O N   XXI.

S E C T I O N   XXII.

S E C T I O N   XXIII.

S E C T I O N   XXIV.

S E C T I O N   XXV.

E X P E-

EXPERIMENTS, &c.

SECTION I.

*The Preparation of pure Acetous Acid, and
Acetated Vegetable Alkali, or foliated
Earth of Tartar.*

THE falt called foliated Earth of Tar-
tar is generally made in the manu-
factories from which the fhops are fupplied,
with pearl-afh and diftilled vinegar, and
therefore contains fome marine falt, and a
portion of the oil of vinegar beyond what
is neceffary to the conftitution of acetous
acid. Thefe extraneous fubftances have
confiderable effect in divers operations, and
are apt to perplex or miflead the Experi-
menter.

B   The

The foliated Earth of the Apothecaries' Hall, being prepared for medicinal ufe only, is indeed tolerably free from marine acid, but by reafon of their obedience to the pharmacopœia, which has adopted none of the recent improvements in Chemiftry, it is neither fo white nor fo free from oil as that of the manufacturers.

For thefe reafons I never employ the foliated Earth of the fhops, except for producing a large quantity of Acetous Acid, which by the following treatment I obtain in the pureft and moft concentrated ftate.

To a convenient quantity of oil of vitriol in a glafs retort, an equal weight of the foliated Earth of Tartar, is to be gradually introduced in fmall pieces, and at fuch intervals, that the heat excited fhall never exceed 100 degrees of Farenheit. If in thefe intervals the mouth of the retort be loofely ftopped, little or none of the acetous vapour efcapes; for it condenfes in the upper part and neck of the retort, and if this laft be duly placed, returns into the charge.

When

When about one-third of the foliated
Earth is introduced, the vitriolic acid con-
cretes with it in cooling, and both occupy
the bottom of the retort; then the remain-
der may be introduced at once, without
caufing any heat or commotion. Thus the
falt covers the vitriolic acid, and intercepts
any portion of it which might otherwife
arife when the charge is heated.

A fmaller quantity of vitriolic acid may
ferve; but as an excefs of it is neceffary
for the total decompofition, and this quan-
tity renders the charge more fufible, I pre-
fer it as promoting equable mixture in a
moderate heat, and preventing that decom-
pofition of acetous falt which it undergoes
by heat alone, without affording any acid
from the portions which efcape the action
of the vitriolic acid.

The Retort is then to be fet in a fand
heat, and luted to a long neck, terminating
in a tubulated receiver, which delivers
its contents through the tube into a bottle,
that may be removed at pleafure, in or-

der

der to keep the fucceffive products apart.
No luting ought to be ufed where the tube
enters the bottle; becaufe the dilated air of
the veffels, or the elaftic fluids expelled, will
force the luting, if the egrefs elfewhere be
prevented, and becaufe there is never any
fenfible lofs of a condenfible vapour, whilft
the receiver is cool, and the only paffage
is between the contiguous furfaces which
the tube and bottle prefent to each other.

The diftillation is to be carried on very
flowly at firft, left the falt laft added, by
fuddenly falling into the liquefied vitriolic
mafs beneath, fhould excite fo much heat
and intumefcence as to endanger the veffels,
or emit the acetous vapour quicker than the
long neck and recipient can condenfe it.

When as much acetous acid as amounts
to half the weight of the acetous falt is
diftilled, the bottle is to be removed; and
what follows, until a white fulphureous va-
pour fhews itfelf in the long neck, is to be
received in another. This laft portion of
acetous acid is weak, and flightly impreg-
nated

nated with volatile vitriolic acid, from which it cannot eafily be freed. It is therefore to be kept apart.

The former portion is eafily purified from the marine acid which rifes along with it, in confequence of the decompofition of the marine falt contained in the acetous falt, by diftilling it from a twelfth part of frefh Ter. Foliata. In this cafe there is an encreafe of the quantity of acetous acid proportionate to the quantity of marine acid abforbed by the alkali of the foliated earth, and ex- pended in decompofing it : and the acetous acid is obtained in a ftate of purity and high concentration, becaufe this acid is more vo- latile than water, and the undecompofed part of the acetous falt retains the water until the chief part of the acid is diftilled. I generally referve the firft half of this acet. acid for accurate experiments, diftinguifhing it by the name of Purified Acetous Acid, and fometimes, where my notes are literally tranfcribed, it is called my Acetous Acid; the other half ferves for any purpofe in

which

which the purity but not the ftrength or fpecific gravity of the acid is regarded.

To prepare Terra Foliata Tartari of a purer kind, and which, after the example of the celebrated Bergman, I fhall call by the more unexceptionable name of Acetated Vegetable Alkali, I faturate a folution of purified alkali of Tartar, with my purified acetous acid, and evaporate the neutral liquor until it is capable of forming a dry white falt, when cold ; in which it never fails, if the evaporation be very flowly conducted towards the end, in a heat not exceeding 212 degrees ; and if it be cooled very flowly.

In the preparation of this falt, the following particulars are to be noticed :

In four ounces Troy, or 1920 grains of falt of Tartar, freed from earthy matter, there are 1344 grains of mere alkali, and 576 of fixable air and water.

To

To this alkali an equal weight of water
is added, in order to keep the intended neu-
tral falt in folution, without which the
point of faturation cannot be afcertained.
The ftrongeft and pureft acetous acid, whofe
fpecific gravity is 1,068, is then poured in,
in fmall portions, at diftant intervals, to
prevent wafte by the intumefcence and ra-
pid emiffion of the fixable air of the alkali,
until it is faturated : the faturation is not
effected until 1900 grains of the acid are
expended.

On evaporating the neutral faline liquor,
it continually exhales acetous acid, even
when the heat does not amount to 200 de-
grees. When a dry froth forms on it to
the depth of a quarter of an inch, or when
a drop taken up on a glafs rod fets quickly,
and when cold feels dry and pulverable,
the evaporation is to be difcontinued; for a
further continuance or augmentation of
heat will decompofe the faline matter, and
blacken it. At this period, it is the re-
quired falt in a ftate of fufion, which on
cooling gradually concretes into a fnow

white

white dry pulverable mafs, fimilar to Ter.
Foliata in the cryftaline luminated and fil-
very appearance which it prefents when
broken into pieces ; and being equally de-
liquefcent, it ought to be guarded from the
air.

The dry falt now weighs 2672 grains ;
1344 grains of which being mere alkali,
the remaining 1328 grains are acetous acid
and water ; and the wafte of acetous acid
during the evaporation amounts to about
572 grains.

Thus it appears, that even vegetable al-
kali does not retain as much acetous acid,
in the form of a dry falt, as is neceffary to
neutralize it in water.

S E C T.

S E C T. II.

Phlogiston is a constituent Principle of Ace-tous Acid.

THE purest concentrated acetous acid is inflammable, but not in a high degree; for by reason of its volatility, and of the water inseparable from it in this form, it eludes in a great measure the ignition necessary for its combustion. But when it is detained by lime, magnesia, metallic substances, or alkaline salts which previous to their combination with this acid were perfectly incombustible, and is sufficiently heated in contact with air, it gives decisive evidence of its combustibility, and shews that Phlogiston is a constituent principle of this acid.

This appears in the most striking manner, in the following experiment:

I saturated fixed vegetable alkali, which had been well calcined, and was perfectly incombustible,

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incombuftible, with pure acetous acid, and by evaporation prepared the dry acetated vegetable alkaline falt already defcribed. Having then taken the weight of a red-hot fhallow earthen difh, after it had been kept two hours in this heat, I placed it in a reddened muffle, and threw on it in fuc-ceffive portions eight ounces Troy $= 3840$ grains of the falt, to which air was freely admitted, during the whole time.

The falt firft melted like wax, with a flight hiffing, until fome moifture was ex-pelled ; foon after it was compleatly fufed, it catched fire, and burned with a denfe bright durable flame of great volume, and which afforded no vifible foot.

After the flame had ceafed, that is to fay, after the emiffion of combuftible vapour or elaftic fluid from the falt had flackened con-fiderably, a black alkaline coal remained, which was ftill flowly and weakly com-buftible, and foon became white on the furface expofed to the air. After half an
hour's

hour's red heat, this falt weighed 2544 grains.

When it was cooled, the whitenefs was found to have extended but very little into the mafs, which was black every where, except in the furface expofed to the air.

It tafted and diffolved in water like mild fixed vegetable alkali; but the folution was turbid, and blackened by a light coaly powder; which feparated by filtration, and wafhed repeatedly with diftilled water, in which it was not at all foluble, weighed when dry, 30 grains. It refembled fine tinder, catched fire freely from a fpark, and burned without flame like tinder, until it was reduced to grey afhes, which by flight calcination became incombuftible, and were found to be mild fixed vegetable alkali weighing four grains.

The liquor from which this tinder was filtrated, was not found to contain any thing worth notice, except fixed vegetable alkali, combined with fixable air.

Hence

Hence it was inferred, that Phlogiſton is a conſtituent part of acetous acid, and that after a great part of the Phlogiſtic matter of this acid is expelled from the fixed vegetable alkaline baſis of the acetous ſalt by a red heat, and is expended in the luminous flame and aerial products, a conſiderable portion of the like matter is obſtinately retained in the alkali, wherever the free acceſs of air is interrupted ; and that the portion of alkali which remains fully impregnated with this matter, forms with it a black coaly ſub-ſtance, which is inſoluble in water, and freely combuſtible, but without exhibiting any flame ; and which conſiſts of about one part of mere vegetable alkali, combined intimately with fourteen or more of pure or compounded Phlogiſtic matter of acetous acid.

To try whether the acetous acid derives its combuſtibility, and its capacity to form a combuſtible ſubſtance or tinder with al-kalies and indeed with all other bodies with which it is combinable, from ſome volatile oily matter which is expelled along with

with it, in the decompofition of the ace-
tated falt, and which may not be an effen-
tial ingredient of this acid; I have com-
bined the pureft part of it with alkali again,
and detached it by different mineral acids,
and repeated the combinations of it with
alkalies, lime, and magnefia, and the de-
compofitions whereby it was feparable from
them, five or fix times; but ftill found that
any falt made with it, and particularly the
foliated falt, was ftill as combuftible as
that prepared in the manner defcribed in
the Firft Section.

Wherefore I conclude, without awaiting
the further proofs which follow, that ace-
tous acid cannot exift, poffeffing the form
and characters by which we diftinguifh it
from others, without a confiderable quan-
tity of Phlogifton, and that Phlogifton is a
neceffary principle in the compofition of
this acid.

S E C T.   III.

*Analyſis of Acetated Vegetable Alkali by
Fire, and Inductions relative to Acetous
Acid, Fixable Air, Inflammable Air, Phlo-
giſton, and Fire.*

THE apparatus employed in the fol-
lowing experiment conſiſts of a tu-
bulated receiver, whoſe neck is 12 or 18
inches in length, and duly tapered to re-
ceive the neck of the retort, to which I ge-
nerally cement it with a paſte made of li-
quid glue and freſh powdered lime, which
ſoon acquires a ſtony hardneſs, adheres per-
fectly, is impervious to elaſtic fluids, and
is eaſily removed after being ſteeped for
ſome hours in marine acid. By the length
of the neck the body of the receiver is kept
at a ſufficient diſtance from the hot walls
of the furnace; and by its tube it enters
the mouth of a ſeparating funnel to which
it is accurately ground. The tube is made
in the receiver in the part which is loweſt,
when it is ſet for diſtillation, and by this

3   means

means all that is condensed runs immediately into the separating funnel, which is provided with a glass cock at the pointed extremity, by the use of which, the succeffive or different products of the diftillation may be drawn off into bottles which fit the extremity of the separating funnel, without suffering any elaftic fluid to escape that way, or any external air to communicate with the contents of the veffels.

In the upper hemisphere of the separating funnel, an aperture ftrengthened with a neck of glass is provided, into which one extremity of a bent glass tube is well fitted by grinding, fo as to be perfectly air tight, whilst the other extremity, by the due flexure of the tube, enters a trough of water or mercury, through which it may freely deliver any elaftic fluid into the veffels intended for the menfuration of it.

Thus the mixture of elaftic fluid and condenfible vapour which iffues from the charge of the retort, is forced to pafs firft through the long narrow and cool neck of
the

the receiver, to circulate in the spacious body of it, to pass again through its narrow tube, to circulate again in the separating funnel; and finally, after depositing all that can be condensed under these advantageous circumstances, the incondensible part passes off through the narrow bore of the bent tube.

Into a strong crown glass retort, well coated with clay, I introduced 16 ounces Troy = 7680 grains of my acet. veg. alkali, consisting of 3862.994 of pure alkali, and 3817.006 of acetous acid and water; and knowing by former experiments that it is impossible to heat this salt to any considerable degree, without boiling it over into the neck of the retort, unless the fire be applied in such a manner as to make the upper part of the vessel hotter than the bottom, I placed the retort on the sand-bed of a reverberatory furnace, with the uncoated extremity of its neck projecting a few inches through the door: and having adjusted the apparatus lately described, to

the

the uncoated part of the neck, I fecured
the juncture with glue lute.

The furnace was then gradually heated,
and the heat uniformly encreafed during
fix hours.

The quantity of common air in the re-
tort and condenfing veffels was 346.5 cubic
inches; and the veffels which were ready
for meafuring the incondenfible product of
this charge contained nine cubic inches
each.

On the firft impreffion of the fire, the
air in the retort being dilated, a portion of
it iffued, which at the temperature of 52
of Farenheit, and under the mean preffure
of the atmofphere, meafured 36 cubic
inches, and was not different from common
atmofpheric air. Now water began to
fhew itfelf in the recipient, and was after-
wards collected to the quantity of 120 grains,
when about 63 cubic inches more of com-
mon air had iffued. The water was not
in the leaft degree acid or coloured, but

fmelled

fmelled and tafted like the oil hereafter de-
fcribed. The laft portions of the 63 cubic
inches of air, were fit for combuftion, but
in this refpect not quite fo good as common
air, and fmelled like the water. At this
period, the emiffion of air was fuddenly
followed by a preffure of the external air
into the veffels, which would have forced
the water, in which the bent tube was im-
merfed, into them, if I had not inftantly
turned it out of the water, and admitted
the air through it.

In diftilling any body which contains
water, it is to be obferved, that the air in-
cluded in the retort and recipient will be
dilated and expelled for the greater part, if
not totally, by the watery vapour; and
when that vapour no longer iffues in due
quantity, to fill the veffels and counteract
the preffure of the atmofphere, the external
air preffing on the veffels, will prefs into
them, wherever it finds admittance; but if
the communication is intercepted only by
water, or any other fluid, that will be
preffed into the recipient, and even into
the

the retort, fo foon as the emiffion of hot
vapour from the charge is infufficient to fill
the fpace which the vapour formerly occu-
pied, after expelling the air.

If external air be admitted to prevent the
water from being preffed into the recipient,
the quantity of it will be equal to that for-
merly expelled, provided the diftillation be
very flowly conducted, as in the prefent
inftance. Therefore rejecting from the fol-
lowing meafurement the air heretofore ex-
pelled, fince it was not altered in any con-
fiderable degree, we are now to confider the
charge as confifting of 7680 grains of the
falt expofed to 346.50 cubic inches of at-
mofpheric air; both which amount to
7813.4 grains.

When the frefh emiffion of air took place,
and amounted to 40 cubic inches, I began
my reckoning in the following manner :

Cub. Inch. contained.	Of fixed Air.	Of Phlogifticated.	Of Inflam.
Firft 40	6	30	4.0
Next 160	26.7	100	33.3
160	32.	80	48.
160	40	40	80

The

The water now faved amounted to 340 grains, and ethereal oil began to condenfe with the laft portions of it, for no more water, feparable from the oil, appeared after this period.

Cub. Inch. contained.	Of fixed Air.	Of Phlogifticated.	Of Inflam.
Next 160	40	20	100
320	80	10	230
320	80	0	240
320	53.5	0	266.5
320	46.	0	274
320	45.7	0	274.3
320	45.7	0	274.3
320	45.7	0	274.3
320	40.	0	280
320	35.5	0	284.5
320	32.	0	288.
320	32	0	288.
320	21.3	0	298.7

Before this period, the diftillation of oil had ceafed, and now I drew off all that was condenfed. It weighed 180 grains.

160	8	0	152
64	2.1	0	61.9

The

The laſt portion of elaſtic fluid iſſued ſo
ſlowly, although the fire was augmented,
and the retort ſhewed a bright red heat,
that very little more was to be expected :
I therefore withdrew the fire. The elaſtic
fluid left in the retort and recipients mea-
ſured, when cold,

Cub. Inch. contained.	Of fixed Air.	Of Phlogiſticated.	Of Inflam.
277	15	0	262
Total 5021	727.2	280	4013.8

The inflammable air thus produced, dif-
fers greatly in ſpecific gravity from that of
metallic ſolutions; the firſt portions ex-
pelled by moderate heat are much heavier
ſpecifically than thoſe which follow at diſtant
intervals, and thoſe that are expelled by the
greateſt heat at laſt, are the lighteſt, but
yet greatly exceed the inflammable air from
metals, in denſity and weight.

As it is not neceſſary to my preſent pur-
poſe, that my menſurations ſhould be per-
fectly accurate, I ſhall not inſiſt further on
theſe differences of the ſpecific gravity of

the

the inflammable air of acetous falt, than to remark, that a mixture of the firft and laft portions is, according to my experiments, to atmofpheric air, in fpecific gravity, as 19 to 28.84189, and that a cubic inch of this mixture weighs .261 gr. when it is frefh, but freed from fixable air by lime liquor.

	Gr.
Stating a cubic inch of this in- flammable air at – – –	0.261
A cubic inch of phlogifticated air, according to Fontana, at – –	.377
A cubic inch of common air, at -	.385
A cubic inch of pure air, called dephlogifticated air, at – –	.42
And a cubic inch of fixable air, at	.57

	Grains.
In the products of the acetous falt, I find, of fixable air -	414.504
Of phlogifticated air – –	105.56
And of inflammable air – –	1047.6018
Total	1567.6658

On the firft emiffion of fixable and in- flammable air, a denfe white fume fills the long neck and receivers ; and thefe elaftic fluids,

fluids, as they iffue through the water into the meafures, fill thefe laft with fume of the fame kind, but not equally opaque. But when the elaftic fluids have ftood a few minutes, a very fmall quantity of oily and aqueous matter is depofited, and they become tranfparent. The quantity of oily matter depofited by 100 cubic inches, was too fmall to be meafured, but fome allowance is to be made for it.

During this procefs, the long neck was cool to the touch within fix inches of the luting, at the mouth of the retort, and in all diftillations that I have made, in which elaftic fluids of any kind are flowly expelled, the heat extends very little farther in the receiving veffels than it would by the approximation of fuch veffels to the heated retort, if it were quite empty; but condenfible vapour carries the heat with it to a confiderable diftance, and as far as it extends in the ftate of vapour, from the retort into the extreme condenfing veffels. Hence it appears, that elaftic fluids retain the fire which iffues with them, in a ftate

of

of combination, and by virtue of the at-
traction which caufes this union, prevent
the efcape or diffufion of this fire into the
neighbouring bodies or fpaces ; and as this
phenomenon is common to all the elaftic
fluids, and almoft all experiments in which
they are flowly produced, it ftrongly indi-
cates that a great quantity of fire is com-
bined in every one of them, and is to be
confidered as a conftituent principle and
active ingredient.

On breaking the retort, I found a fpongy
mafs, of a black or deep blue colour on
the upper furface, and dark grey in the
mafs, refembling in all refpects the black
alkaline coal of tartar. It adhered to the
glafs, and when feparated by folution, was
found to weigh 5524 grains ; but as the
glafs had been manifeftly corroded in fe-
veral places, it muft have contributed to
this weight,

The folution of this alkali fhewed a con-
fiderable bulk of light black coaly matter,
which

which was eafily feparated by filtration from
the alkaline liquor which paffed limpid,
and when wafhed and dried, weighed 86
grains. It was very like lamp black,
catched fire readily like tinder, and burned
without fmoak or flame to grey afhes,
which by calcination grew whitifh, or pale
yellow, and melted in a weak red heat.
The melted matter confifted of vegetable
alkali and a little fixable air, and weighed
8 grains; therefore the quantity of volatile
combuftible matter was about 78 grains.

The filtered alkaline folution from which
the coaly matter was feparated, was milder
and feemed to contain more fixable air than
is in ordinary falt of Tartar. In divers ex-
periments it appeared to differ in nothing
elfe from purified falt of Tartar ; and even
before the coaly matter was feparated, it
did not act like phlogifticated or Pruffian
alkali. By neutralizing it with diluted vi-
triolic acid, I expelled from it 1858 cubic
inches of fixable air = 1059.06 grains,
which added to 414.504 obtained in the
diftillation, make 1473.564 grains.

Of

Of 346.5 cubic inches of atmospheric
air included in the vessels, $\frac{4}{5}$ were phlo-
gisticated air, the weight of which is 104.5
grains; and the weight of the pure air in
this quantity of atmospheric air is 29.1
gr.: but since this quantity of phlogisti-
cated air is almost equal to that which was
expelled along with the inflammable, and
we know that phlogisticated air is in no
respect altered or active in processes of this
kind, we shall reject it as well from our
statement of the charge, as from that of the
products; and say, that the charge con-
sisting

	Grains.
Of mere vegetable alkali - -	3862.994
Of acetous acid and water -	3817.006
Of pure air - - -	29.1
And altogether amounting to	7709.100
Yielded of mere alkali - -	3862.994
Of fixable air - - -	1473.564
Of inflammable air - -	1047.6018
Of oily matter held in the black coal - - -	78.
Of oil - - -	180.
Of water condensed - -	340.
These amount to - -	6982.1598

3

Which

Grains,
Which is lefs than the charge by 726.9402

This deficiency puzzled me exceedingly,
until by repeated experiments fimilar to
this, I found that it is always owing to the
water and oil, and chiefly to the water
which follows the ftream of elaftic fluids,
and of which a fmall part remains fufpended
in them for a confiderable time after they
acquire the temperature at which I mea-
fured their bulk, but not their weight.

Applying thefe experiments to my pre-
fent purpofe, I may, wthout any confider-
able error, ftate the quantity of water car-
ried off in vapour, and not included in the
foregoing weight, at 700 grains; and the
quantity of oil carried off in the fame way,
at 26.9402 grains.

The quantity of water which the 29.1
grains of pure air can furnifh in thefe cir-
cumftances, is too fmall to be regarded on
this occafion; and therefore we may fay
that the acetous falt contained 340 + 700
= 1040 grains of water, and confequently
2777.006

2777.006 of mere acid, or mere acid and fixable air : for I ftrongly fufpect that in the mere evaporation and exficcation of the falt, fome fixable air is formed from the acetous acid where it is expofed to the air.

It is to be obferved, that the inflammable air, oil, and phlogiftic part of the black coal, amount to 1332.542 grains; and the fixable air to 1473.564 grains; the total of which differs from 2777.006, the computed quantity of mere acid, only by the weight of the pure air, which never fails, with ignited acetous falts, to make fixable air. From all which I conclude, that the quantity of matter, in acetous acid thus treated, which is expended in the formation of inflammable air and oil, is not much lefs than that which is expended in making fixable air; and for the reafon above-mentioned, I am of opinion that the weight of thefe would be equal, if the acetous falt were prepared without expofure to air, which fo far as it enters will make fixable air, as will be fhewn hereafter.

In

In this experiment we remark the moſt illuſtrative phenomena of a great many more which I have made on ſalts and vegetable ſubſtances, containing the principles of acetous acid; in all which it appears that phlogiſton enters the compoſition of acetous acid in great quantity; that acetous acid detained by its attraction to a fixed body, until it is ignited to a certain degree, forms new compounds; that fire is the only mat-ter which it receives in this circumſtance; that it abſorbs and combines with this fire, and fixes it; that ſome principle or prin-ciples of the acetous acid combined with fire make fixable air, whilſt ſo much of the re-mainder as combines in like manner with fire makes inflammable air; and that which eſcapes the neceſſary ignition makes oil; or that which is obſtinately retained in a fixed body makes a coaly combuſtible ſubſtance.

But above all things we are to obſerve, concerning the diſtillations in which acetous acid is ſubmitted to the action of fire, that no part of it either in this or any ſimilar expe-riment is expelled from acetous ſalts duly

prepared,

prepared, in the form of acetous acid, and that the acidulous liquor, which is faid by chemical writers to be diftilled in fuch proceffes, is not truly acid, but a mixture of water, fixable air, and the ethereal oil of the fubftance fubmitted to the diftillation.

Finally, it is to be remarked, that in this or in any of the diftillations of acetous compounds, made by the ableft chemifts, there is no increafe of weight in confequence of the new compounds formed by the acetous acid and fire; and confequently all fuch experiments tend to fhew that the matter of fire does not gravitate fenfibly.

S E C T.

S E C T. IV.

Experiments shewing that in the Tranf-mutation of Acetous Acid into the Elaftic Fluids and Oil, there is no intermediate Form of it, and tending to eftablifh the foregoing Inductions.

IN diftilling 16 ounces Troy of acetated vegetable alkali in a glafs retort fet in a fand pot, the abforption of air took place in the manner defcribed in the preceding experiment. Fixable and inflammable air iffued alfo after the falt had been compleatly fufed, and the abforption had ceafed, but the proportion of fixable air was fomewhat lefs relatively to the inflammable air, from the beginning to the 2340 cubic inch of the mixed elaftic fluids ; which I impute to the different application of heat.

For here any fixable air, detached from the hotteft part of the charge near the bot-tom of the retort, muft pafs through the

<div align="right">frothy</div>

frothy and colder parts, in which a great part of it may be retained, whilst the inflammable air which is lefs forcibly attracted by the alkalefcent charge, efcapes through it undiminifhed.

When about 3000 cubic inches of elaftic fluid were expelled, the quantity of water and oil was nearly the fame as appeared at the like period of the former experiment; and now the charge boiled over the helm.

This inconvenience was repeatedly experienced in diftilling the fame falt in this manner, although I had ufed retorts capable of holding fix times the charge, and had regulated the fire with the greateft caution.

The part of the charge which had not boiled over, was a black fpongy alkaline mafs, which, when diffufed in water, eafily depofited a black coaly matter, like that defcribed in the foregoing experiment, on the filter, whilft the alkaline folution paffed through quite colourlefs.

This

This filtered folution evaporated to dry-
nefs, yielded pure white and very mild fixed
vegetable alkali, which on the affufion of
vitriolic acid, yielded a greater proportion
of fixable air than is above defcribed, as
might be expected in confequence of the
heat which it fuftained being much weaker
and of fhorter duration.

The portion which boiled over, and con-
fequently fuftained the leaft heat, was as
deliquefcent as the acetated alkali employed,
and was of a dark brown colour, as if ftained
by the oil expelled from the part of the falt
which occupied the bottom and hotteft part
of the retort. The folution of it paffed
flowly through the filter, and was opaque,
olive-coloured and greafy, by reafon of the
oil. The dry falt got from it by flow eva-
poration, was plainly impregnated with oil,
which gave it the colour of pale yellow
ochre. Its weight was exactly half that of
the white alkaline falt got from the other
part of this charge; and with vitriolic acid
it yielded fixable air and acetous acid,
which left a refidue of vitriolic falt, black-

D   ened

ened by the oily matter. Therefore, the part of the acetous acid which was fufficiently ignited, was all tranfmuted into elaftic fluids and oil, and the remainder retained the form and characters of this acid ; and in the tranfition of acetous acid to form fixable and inflammable air and oil, there is no intermediate form of it ; and as the oil may by fire alone be turned into inflammable air, the part which appears in the oily form differs from the inflammable air chiefly in its having efcaped the neceffary ignition, and confequent difunion of its parts, which muft precede its combination with the quantity of fire effential to the elaftic form of inflammable air.

In repeating this experiment with 64 ounces of acet. veg. alkali, I obferved the fame phenomena on a larger fcale, and did not obtain one drop of acid. But yet the water impregnated with fixable air and ethereal oil had a pungent acidulous tafte; which has mifled chemifts to confider the like product of acetous falts and vegetable fubftances as an acid fpirit.

In thefe circumftances; the acetous acid does not part in its proper form and conftitution from the alkali ; but remains in it, until by the accefs of a certain charge of fire, it forms the new products which pafs off in diftillation.

In the foregoing manner, 32 ounces Troy of my acetated vegetable alkali were diftilled, very flowly, and yielded the water, oil, fixable air, and inflammable air, already defcribed ; until, at the expiration of fix hours, the charge begun to froth and rife towards the helm : then the retort was quickly raifed out of the hot fand, without expofing its contents to the atmofpheric air. When the matter had fubfided a little, and concreted by cooling, it was very fpongy at the upper part, but as compact as the foliated Earth of Tartar at the bottom, and equally cryftaline, foliated, and deliquefcent; but it was of a dark grey colour, and weighed 26 ounces : therefore, only fix ounces were expelled in the forms above-mentioned : but in reducing the acetous falt to this ftate, all the water that could have been withdrawn

without

without decompofing it totally, was taken from it.

To thefe 26 ounces I added, very flowly, through a feparating funnel, in a tubulated retort fitted to the apparatus defcribed in the Third Section, 26 ounces of the moft dephlegmated vitriolic acid, every part of which excited heat, where it acted on the faline mafs. By diftillation in a fand heat, I obtained firft, three ounces of dephlegmated acetous acid ; then as much more of weaker acetous acid ; then two ounces, of which one-third was water ; and laftly, an ounce of acid, equal to dephlegmated acetous acid mixed with its weight of water. ·

During the diftillation of the acid, a denfe white vapour flowed down along the lower fide of the long neck and receiver, confifting chiefly of acetous and oily vapour and fixable air; and the elaftic fluid which iffued through the bent tube of the lower recipient, after the atmofpheric air was expelled, confifted of fixable air blended with a little of the oily and acetous vapour. After this, half

half an ounce of water, impregnated with vitriolic and fulphureous acid, was diftilled, and then the fulphureous or volatile acid, in its elaftic ftate, iffued rapidly. At this moment I raifed the retort out of the hot fand, and fuffered it to cool quickly, without admitting any air to it.

The quantity of water thus procured from the mixture of the moft dephlegmated vitriolic acid with highly dephlegmated acetous falt, from either of which feparately, no water can be procured by heat, is worthy of notice. The true reafon of it will appear hereafter; but when the experiment was made, I imputed it to the agency of Phlogifton, which in divers experiments appeared to facilitate the extrication of water from acids, air, and other bodies; and although I could not determine whether the water was only liberated, or was really formed, I made practical ufe of the obfervation; for ever after, in preparing the ftrongeft acetous acid, I was little folicitous about the drynefs of the acetous falt, or ftrength of the vitriolic acid, and trufted

chiefly

chiefly to the volatility of the acetous acid, by reafon of which, the firft portions diftilled from a great charge are as ftrong as acetous acid can be procured from the drieft materials.

The denfe white vapour which occurs in the diftillation of this and other acetous compounds, runs diftinct under the air left in the veffels, as water runs under oil, and confifts of fixable air blended with oily vapour. Whilft the acid arifes highly dephlegmated, this fine oil is freely imbibed by it, to a certain quantity; but the diluted acid which follows, becomes turbid with the oil, becaufe it is foluble in water only, in fmall quantity.

Hence we learn, that the oil or moft phlogiftic part of acetous acid will unite with the like acid, although the phlogiftic part, which has acquired the form of inflammable air, will not. And as this oil may be tranfmuted into inflammable air by fire only, the agent which gives the elaftic form is fire, and that which prevents the
phlogiftic

phlogiftic part of acetous acid from uniting
with the like acid again, is nothing elfe but
fire.

The faline mafs, confifting of vitriolic
acid and vegetable alkali, was found ftrongly
impregnated, and quite blackened with
coaly matter, like that already defcribed;
whence it appears, that vitriolated Tartar,
with excefs of vitriolic acid, will retain, like
alkali, a portion of the Phlogifton of acetous
acid in a confiderable heat, and will form
with it a black coaly fubftance.

The fulphureous acid fhews that the
phlogiftic matter of acetous acid, volatile
fulphureous acid, fulphur, and other bodies,
is identical.

From this and the foregoing experiments
we may infer, that the fire expended in
decompofing acetous acid, paffes off along
with the products in a fixed ftate, fince they
iffue cold; and that every portion of the
acetous acid requires its due charge of fire,
before it can be tranfmuted by it; fince by

withdrawing

withdrawing the charge of acetous falt from the fire, at any time before the whole of its acid is transformed, whatever part of it remains, is still poffeffed of every property of acetous acid, and affects no condition intermediate between this and the fubstance of elastic fluids, which with a due charge of fire it never fails to form.

This is manifestly true, with refpect to the part of the acetous acid which is expended in the formation of fixable air; but as fome of the phlogistic part of the acetous acid is expended in forming oil, whilst the remainder of its phlogistic matter, in new combination, forms inflammable air, the part which is turned into inflammable air, may be faid to affect an intermediate form of oil, although the fame may not be faid of the acetous acid; but still the oil appears to be nothing more than the fubstance of inflammable air before it combines with fire; for this oil pushed through red hot fand or glafs, or clay, or detained in porous bodies by capillary attraction, until it can be duly ignited, is almost wholly con-
vertible

vertible into inflammable air, like that ex-
pelled from the acetous falt.

In due time, we fhall difcover the reafon
why one part of the acid is expended in
making fixable air, whilft the remainder
forms a combuftible elaftic fluid or oil, fo
different from acetous acid or fixable air.

In thefe diftillations of acetated vegetable
alkali, and in thofe of other acetous falts,
in glafs veffels, I have always found that
more of the fixable air is retained in the
alkaline or earthy refidue, than is expelled
along with the inflammable air.

In fixable air, whofe parts are detained
and approximated by an alkaline falt, as in
our mild alkaline refidues of acetous falt; or
by earth, as in chalk or magnefia; the mat-
ter of fire does not feem to be combined in
fo great a quantity as in that which affumes
the elaftic form ; but ftill we may be al-
lowed to call it, even in the fixed ftate, by
the ufual name, and in the latitude of fpeech
which muft be admitted in the infancy of
this

this knowledge, we may fay, that fixable air never becomes elaftic, until it is faturated with fire, and unreftrained by other matter; for in detaching it from alkalies, chalk, magnefia, or any other body, fo as to produce it in the elaftic ftate, we are obliged to ufe fire; we obferve a great expenditure of fire, becaufe the body thus yielding fixable air, never conceives near fo much heat, whilft it emits fixable air, as it would in the fame fire, if it contained none of this matter; and the fire which thus accompanies fixable air does not defert it, becaufe it does not warm the veffels through which the fixable air runs with a rapid ftream : or if we attempt the extrication of fixable air by any other means, we find that nothing void of fire will anfwer the purpofe. Acids caufe great heat, and confequently emit a great quantity of fire in combining with pure alkalies, pure calcareous earth, calcined magnefia and divers other bodies; therefore they contain fire abundantly : but when acids are employed to detach fixable air from thefe bodies, little or no heat is difcoverable, no fire is emitted to wafte, but all that belonged

to

to the acid or alkali, or lime or magnefia, and which cannot be retained in the faline compound, is transferred to the fixable air and combines with it; for otherwife, it would iffue hot, and gradually impart this heat to the neighbouring bodies.

Whenever any heat is difcovered in the folution of bodies which yield fixable air, and very little elfe, it implies no more than that the menftruum and folvend together emit more fire in the approximation and union of their parts, than is neceffary to the conftitution of that quantity of fixable air which iffues in the elaftic form.

<div align="right">S E C T.</div>

S E C T. V.

*Analyfis of Acetous Calcareous Salt by Fire,
illuftrated with general Obfervations.*

I HAVE purpofely omitted the doubts
which may be entertained concerning
the foregoing inferences, left they fhould
perplex the reader, and referved the dif-
cuffion of them for the fubfequent pages,
in which I am to relate the experiments
made for this and other purpofes.

Sufpecting that the alkali of the acetous
falt might have contributed to the formation
of the elaftic fluids, and of the oil efpecially,
by fome other means than the mere deten-
tion of the acetous acid, until it receives a
greater charge of fire than that by which it
may be diftilled alone without decompo-
fition ; and intending that the meafures, by
which the real agency of the alkali might
be afcertained, fhould at the fame time
afford fome further elucidation of the nature

of

of this acid, I made the following experiments with new acetous compounds.

Into a cylindrical glafs veffel, filled with mercury, and inverted in a bafon of the fame, I introduced 240 gr. of powdered lime, and when it had all rifen above the quickfilver, I added 720 gr. of concentrated acetous acid, which with a glafs rod I mixed brifkly with the lime. A heat exceeding 212 degrees was immediately excited, and the mercury was depreffed confiderably.

The matter which depreffed it, occupied a fpace of 18 cubic inches, under the mean preffure of the atmofphere, whilft it was hot; and was chiefly acetous vapour; for the fpace leffened quickly as the veffel cooled, and the mercury foon rofe to its former heighth.

By this experiment I difcovered the caufe of the great wafte of acetous acid which I had often experienced, in attempting to make acetous calcareous falt without ufing

I   water,

water, in order to fave the trouble of eva-
poration, or to know the degree of concen-
tration or ftrength at which the acid was
contained in the fubject to be fubmitted to
the action of fire : even when the acid di-
luted with an equal weight of water was
mixed with quicklime, I obferved a confi-
derable wafte of the former in pungent va-
pour, expelled by the heat of the flaking
lime, before the intended combination could
take place.

When I diluted concentrated acetous acid
with equal parts of water, and diffolved a
little lime in this weakened acid ; and then,
in order to have a dry falt directly, poured
it on quicklime, I obferved that the parts
of the lime which were moft heated grew
black. This is analogous to the change
which acet. calc. falt undergoes in the like
heat in clofe veffels; and hence I learned,
that in compofing this falt, the lime ought
to be previoufly flaked and cooled, and a
quantity of water, more than is fufficient
for the folution of the calc. falt, ought to
be employed, as in the following experiment:

I flaked

I flaked four ounces Troy of pure lime, and when it was quite cold, I added 30 ounces and 8 pennyweights of water, and then 11 ounces 4 pennyweights of concentrated acetous acid: thefe being the neceffary proportions for faturation and folution in the degree of heat excited during the union of the acid and flaked lime, which was about 100 of Farenheit.

I evaporated the folution flowly to drynefs, never exceeding 200 degrees of heat; and obferved that it exhaled acetous acid fenfibly throughout the evaporation, and copioufly, when the faline matter grew confiftent and approached to drynefs, although at this time the heat did not exceed 100. I therefore dried it no further than to render it compleatly pulverable and fit to be eafily introduced into a retort, without wafte. In this ftate it weighed 11 oz. 4 dwts. 4 gr. =

Grains 5380

So it confifted of lime   -   -   - 1920

Of acetous acid and water   -   - 3460

And the lofs of acid by evaporation was about   -   -   -   - 1916

or

or near $\frac{1}{3}$ of the acid employed : and hence it appears, that near $\frac{1}{3}$ more of the acid is required for the folution of lime, than is retained in the dry calcareous falt ; or, that dry acetous calcareous falt retains the acid in a more concentrated ftate than we have it in the pureft concentrated acetous acid. But the exhalation of acid throughout the eva-poration, and the quantity of acetous acid obtainable from acetous calcareous falt, when decompofed by nitrous and other ftrong acids, fhew that there is a real lofs of near $\frac{1}{3}$ of the acetous acid in evaporating this folu-tion to drynefs.

I have often obferved, that acetous cal-careous falt, which felt perfectly dry and was kept in paper loofely folded, fmelled of acetous acid whenever the paper was opened, during two or three months. For this reafon, and becaufe the acid varies in quantity as the falt is more or lefs dried, I noted the quantity of calcareous earth and acid in the calcareous falt, at the time of my ufing it in any experiment, from which I intended to learn the quantity of fixable

and

and inflammable air, and of oil and water,
which could be produced from it in diftil-
lation.

Of the calcareous falt thus prepared, I
introduced 3965 gr. containing 1438 of
lime, and 2527 of acid and water, into a
glafs retort well coated, and placing it in
a reverberatory furnace, in which the heat
might act equally on the upper and lower
parts of the charge, I adapted a condenfing
apparatus, fimilar to that already defcribed.
The retort and recipients contained 231
cubic inches of common air = 88.935 gr.
and the meafures in which the elaftic fluids
were to be received, contained 37 cubic
inches each.

When fire was applied, the elaftic fluids
expelled were ftated thus:

Cub. Inch.

1.   37 were atmofpheric air.
2.   37 were atmof. air more phlogifticated.

A portion of water and colourlefs ethereal
oil was now drawn off, and marked N° 1,
and a white vapour appeared in the receiver.

E

3. 37

	Cub. Inch. contained.	Fixed Air.	Phlogiftic. and Infl.
3.	37	5	32
4.	37	6	31

Before this time, a portion of clear oil, in-
clining to yellow, was faved apart, and
marked N° 2.

5.	37	12	25

Another portion of yellow oil was now
withdrawn, and marked N° 3.

			Inflam. chiefly.
6.	37	11	26
7.	37	10	27

Now the oil N° 4 was drawn off.

8.	37	9	28
			Inflammable.
9.	37	8	29
10.	37	7.5	29.5
11.	37	7.5	29.5
12.	37	7.5	29.5
13.	37	7.5	29.5
14.	37	7.5	29.5
15.	37	7.5	29.5
16.	37	7.5	29.5
17.	37	7.5	29.5
18.	37	7.5	29.5
19.	37	7.5	29.5

	Cub. Inch. contained.	Fixed Air.	Inflammable.
20.	37	7.5	29.5
21.	37	7.5	29.5
22.	37	7	30
23.	37	6.5	30.5
24.	37	5.5	31.5

No oil appeared to have been diftilled fince the twentieth meafure; I therefore drew off all that was in the recipient, and got none afterwards; this was marked N° 5.

25.	37	5.3	31.7
26.	37	5	32
27.	37	4.9	32.1
28.	37	4.8	32.2
29.	37	4.7	32.3
30.	37	4.6	32.4
31.	37	4	33
32.	37	3.5	33.5
33.	37	3.5	33.5
34.	37	3.4	33.6
35.	37	3.4	33.6
36.	37	3.3	33.7
37.	37	3.2	33.8
38.	37	3.1	33.9
39.	37	3.1	33.9
40.	37	3	34

41.

	Cub. Inch. contained.	Fixed Air.	Inflammable.
41.	37	3	34
42.	37	3	34

Ever after the diſtillation of oil had ceaſed, the vapour in the veſſels was leſs opaque.

43.	37	3	34
44.	37	3	34
45.	37	3	34
46.	37	3	34
47.	37	3	34
48.	37	3	34
49.	37	3	34
50.	37	3	34
60.	370	30	340
61.	37	3	34
62.	37	3	34
63.	37	3.1	33.9
64.	37	3.5	33.5
65.	37	4	33
66.	37	5	32
67.	37	6	31
68.	37	7	30
69.	37	8	29
70.	37	8.5	28.5
71.	37	9	28
72.	37	9.5	27.5

73.

Cub. Inch. contained.	Fixed Air.	Inflammable.
73.	37	9.9	27.1
74.	37	10.2	26.8
75.	37	10.5	26.5
80.	185	52.5	132.5
81.	37	10.5	26.5

At this time the retort was ready to melt, and it was neceſſary to withdraw the fire. What iſſued afterwards was retained in a bladder, faſtened to the diſcharging tube of the ſeparating funnel, and theſe veſſels, when cold, contained 232 cubic inches of air, chiefly inflammable, the calcareous earth, or wet bladder, having imbibed the fixable air, if any iſſued, about the time when the fire was withdrawn.

	Gr.
The ſum of the cubic inches of elaſtic fluids was - -	3229
Of which the atmoſpheric air, un-altered, made - - -	74
The fixable air - - -	456.2
The inflammable and the phlo-giſtic air - - -	2698.8

It is to be obſerved, that in this diſtil-lation, no air in addition to that contained

E 3

in

in the recipients was admitted; for as there was no danger of boiling the calcareous falt over the helm, the retort was quickly heated, and if any abforption of the air happened, its place was fupplied immediately by the vapours and elaftic fluids which iffued early and continually from the charge.

By long experience in operations of this kind, I have been convinced that the quantity of fixable air, which the water can imbibe during the meafurement, is not confiderable, when it is thus mixed with inflammable air, and when the quantity of water employed is not above $\frac{1}{30}$ of the bulk of the elaftic fluids. What is thus imbibed and gradually emitted to wafte from the water is, to my apprehenfion, barely fufficient to compenfate for an inaccuracy, in the menfuration, of a contrary tendency, by which we are led to over-rate the quantity of fixable air. For in the agitation of the mixed elaftic fluid with lime liquor, the quantity of this laft which enters the meafure denotes not only the quantity of fixable air

air imbibed, but the quantity of phlogiftic and inflammable air which is entangled in minute bubbles in the mixture of water and lime; and therefore, if we ftate the bulk of the fixable air to be equal to that of the liquor which enters the meafure, we affume a greater than the real quantity. When the bufinefs is fteadily conducted, thefe oppofite errors correct each other fufficiently, with regard to the fixable air.

Concerning the inflammable air which is thus loft during the feparation of the fixable air, it is to be obferved, that it is barely equivalent to the bulk by which we are apt to over-rate the quantity of this elaftic fluid, in meafuring it foon after it has iffued. For in a mixture of fixable and inflammable airs, iffuing with a temperature exceeding 52 by a few degrees, the inflammable air is more dilated than the other, or requires a longer time to accommodate itfelf to the denfity proper to its mean temperature. Therefore, in meafuring it foon after its egrefs from the charge, I confider the bulk left in the lime liquor as equal or almoft equal to that

by

by which the inflammable air in the mea-
fure exceeds the volume to which it would
in due time contract in a temperate me-
dium.

By frequent comparifons of the bulks of
fuch elaftic fluids, meafured at various tem-
peratures, with their bulks at 52, I afcer-
tained the quantity that ought to be de-
ducted from the meafures taken at any tem-
perature, exceeding 52 ; and this was efpe-
cially neceffary in warm weather, or when
the laboratory was heated. But in making
this deduction from the meafured bulk, I
found it not expedient, for the reafons al-
ready mentioned, that it fhould be greater
with regard to the inflammable than the
fixable air.

Thefe obfervations are applicable efpe-
cially to the prefent experiment, in which
the elaftic fluids were neceffarily meafured
before they had acquired that temperature
to which I confine myfelf in calculating
their weight.

Deducting

Deducting then $\frac{1}{9}$ of the meafured bulk of the elastic fluids of this diftillation, I ftated the mean bulk of the fixable air at 405.512 cubic inches; and that of the inflammable and phlogiftic, at 2398.934.

Of 231 cubic inches of air included in the retort and receivers, 74 were expelled without alteration, and 157 only are to be accounted for: but of this quantity 125.6 cubic inches is the bulk of phlogifticated air, which is merely paffive, and about 31.4 cubic inches of pure air operate in the procefs. Deducting, therefore, 125.6 cubic inches from the volume of the inflammable and phlogiftic air, which was 2398.934, we fhall find the cubic inches of inflammable air alone to be 2272.434.

The pure air meafuring 31.4 cubic inches, and weighing 13.188 gr. and being an active matter, is to be confidered as a part of the productive charge, which confifting of 3965 gr. of calcareous falt, and 13.188 gr. of pure air, amounts to 3978.188 gr.

On

On opening the retort when it was cold,
I perceived that it had been melted, but the
coating had preferved the form of it. The
mafs contained in it was almoft equal in
bulk to the calcareous falt employed : it
was black and fpongy in all parts, except
at the bottom, which prefented a circular
furface, about $1\frac{1}{2}$ inch in diameter, grey
near the centre, but declining to blacknefs
towards the circumference, and the grey-
nefs extended to the depth of $\frac{1}{10}$ of an inch
at the central part only.

This grey part being contiguous to the
fand bed which preferves a red heat for
hours after the fire is withdrawn, was longeft
expofed to the heat; and the change of co-
lour is nothing more than the whole mafs
would have undergone by a further conti-
nuance of the fire, as will appear in fubfe-
quent experiments.

The whole weighed 2191 gr. and ex-
ceeded the weight of the lime contained in
it by 753 gr. Diffolved in dilute marine
acid, it afforded 1160.157 cub. inch. of fix-
able

able air, and 11.5 of denfe inflammable air, which, I believe, was held in the fpongy mafs by capillary attraction : and in the folution it appeared that two or three grains of the glafs adhered to the calcareous mafs. Thus the whole of the fixable air meafured 405.512 + 1160.157 = 1565.669 cub. inch. weighing 892.4313 gr. And the inflammable meafured 2283.934 cub. inch. weighing 596.1067 gr.

After the fixable air was expelled, I feparated the marine folution from the undiffolved coaly matter, which, after being well wafhed and dried, weighed 131 gr. and had great bulk for this weight. It was combuftible, but not freely ; for it could not catch fire from a flint fpark. In the degree of ignition neceffary for its combuftion, in the flownefs of it, and its affording no fmoak or flame, it refembled the powder of culm, which is the kind of mineral coal employed, not as fuel but as a phlogiftic flux of the Cornifh ores of tin. By calcination and frequent agitation in a red heat for three hours, it was reduced to

5   a grey

a grey powder, which clotted in its approach to whitenefs, and was found to be calca-reous earth, impregnated with a little of the marine acid, which was infeparable, by wafhing, from the coaly matter. The cal-careous earth weighed 41 gr. and therefore, 90 gr. of the coaly powder were diffipated, during the combuftion.

When the folution of acetous calcareous falt is infpiffated fo far only as is neceffary for introducing it into a retort, it will ne-ceffarily yield in diftillation a little acetous acid, or nearly that quantity which would exhale in the exficcation of it in open air, fince it is a property of this falt to hold more acetous acid neutralized in conjunction with water, than it can hold in the dry ftate. I have accordingly obferved in divers diftil-lations of acetous calcareous falt, the quan-tity of acid was greater from maffes barely infpiffated, and lefs when the falt was better dried before the diftillation, and leaft of all, or next to nothing, when it was perfectly dried. But as this treatment was attended with wafte of the acid, I preferred the falt

here

here defcribed for the beft experiments; and in my defcription of the phenomena, I am to obferve, that a few drops of the water firft diftilled were four, but that the quantity of acetous acid which thus efcaped undecompofed, was too fmall to require any further attention.

The portion of watery liquor firft diftilled, and marked N° 1, weighed 122 gr, was quite tranfparent and colourlefs, tafted pungent on the firft impreffion and then left a fenfe of coldnefs on the tongue, like peppermint water, and fmelled ftrongly of the ethereal oil which next appeared fwimming on the water. It did not catch fire when approached to flame; but when it was fuddenly heated by pouring it into a hot fpoon, the matter that exhaled from it was inflammable and prefented a weak diffufive flame of very fhort duration : It was nothing more than water flightly impregnated with the fubfequent oily liquor.

The ftraw-coloured oily fluid marked N° 2 weighed 252 gr, fmelled like the
former,

5

former, and had a pungent tafte, refembling
that of acetous ether, but approaching to
caufticity : advanced within a few inches
of the flame of a candle, it catched fire,
even when the air was cold, and burned
with a durable denfe and bright flame,
leaving after flow combuftion about $\frac{1}{10}$ of
its bulk of water, which tafted and acted
in all trials, like water very flightly im-
pregnated with acetous acid.

The yellow tranfparent liquor marked
N° 3 weighed 135 gr, fmelled and tafted
like N° 2, catched fire from a diftant flame,
and burned with a clear denfe and durable
flame, until the whole was confumed, or
what remained after flower combuftion was
only fufficient to bedew the fpoon in fome
parts, or to ftain them to a dull yellow
colour.

In the diftillation of oils expelled from
different acetous falts, there is always a
very fmall refidue of fixed matter, the quan-
tity of which is greater as the procefs for
obtaining the oil is more rapidly conducted,

and

and is greateſt in thoſe circumſtances in which the greateſt abraſion of the veſſels takes place; for glaſs veſſels ſuffer this abraſion from watery, oily, or any fluids long agitated in them during evaporation or diſtillation. In conſideration therefore of the fixed matter which may be protruded along with the oil from an acetous ſalt, by mere mechanical impulſe; and of the abraſion which tends to increaſe the quantity of matter left in the rectification or diſtillation of ſuch oil; I do not repreſent the reſidue in combuſtion as an eſſential part of the oil; and ſince the quantity of it was ſo inconſiderable, I ſhall take no further notice of it.

Nº 4 weighed 178 grains, and differed from Nº 3 chiefly in its richer yellow or ſaffron colour, being leſs tranſparent, and leaving a dew on the ſpoon after combuſtion, which was acidulous and very acrid.

The oil Nº 5 weighed 168 gr. and differed in no particular worth notice from Nº 4, except its greater opacity.

On

On pouring portions of thefe oils to meet in a cylindrical glafs tube, and inverting the ordei of mixture, I could not obferve the appearances which indicate a notable difference of fpecific gravity, although the tenacity or fpiffitude of the oil laft diftilled was much greater than that of the firft limpid portions, which certainly derive fome part of their fpecific gravity from the water contained in them.

That the oily vapour and oil expelled from acetous falts by fire, poffefs an inebriating and fomniferous quality, I long ago fufpected and am now affured by repeated experience : for whenever I fmelled the meafures recently filled, and breathed the air contaminated with them, for half an hour or more, I felt thefe effects ; but they foon ceafed on my retiring into the frefh air.

It now appears, that the ace-   Gr.
tous calcareous falt, weighing - 3965.
And the pure air -   -   - 13.188

Both amounting to -   - 3978.188

Gave the following products :

Fixable

	Grains.
Fixable air	892.4313
Inflammable air	596.1067
Oily matter of the black coal	90.
Ethereal and yellow oil	733.
Water	122.
Lime	1438.
All amounting to	3871.538

The waste of matter blown away along with the elastic fluids is equal to the difference between the sum of the charge and that of the products, and is   106.65

The quantity of oil wasted in the state of vapour out of the recipients along with the elastic fluids, was very small; but in this and all such experiments, the quantity of watery matter which passes off with them is considerable; and there is no reason to apprehend any important error in our stating the quantity last mentioned of 106.65 gr. as water: wherefore the whole of the water amounted to   228.65 Gr.

And the charge yielded of

fixable air and water   1121.0813

Of inflam. air and oily matter   1419.1067

F   It

It will appear hereafter that the pure air, weighing 13.188 gr, contributed to the fixable air and water only, and if we therefore deduct this quantity from 1121.0813, the remainder which is 1107.8933, is the quantity of fixable air and water; and 1419.1067 is that of the inflammable air and oily matter produced from the whole of the acetous acid. Thus it appears that the acetous acid and water, of the calcareous salt, weighing 2527 Gr.

	Grains.
Yielded fixable air and water	1107.8933
Inflamm. air and oily matter	1419.1067
And yielded in all thefe -	2527.

As the firft portions of the oil were found mifcible with water, like ether, and water was depofited in the combuftion of them, and appeared in fome other experiments made with the view of converting it into inflammable air, I am certain that water contributed confiderably to the weight of the finer oil, if it be not an effential ingredient of it.

By a review of this experiment, and thofe of the Third and Fourth Sections, and due confideration

confideration of the eftablifhed principles of chemiftry, we are enabled to make the following obfervations and inferences.

Firft; The acid in the dried acetous calcareous falt retains much lefs water than is contained in dry acetated vegetable alkali; and this is perfectly confiftent with the greater affinity of the latter falt to water; for bodies which contain much water, and yet are dry to the touch and pulverable, evidently hold it by chemical affinity. The quantity of water producible from different acetous compounds, may therefore vary confiderably, but has no ftrict connexion with the converfion of the mere acid into fixable and inflammable air.

Secondly; The oily product is much greater from acetous calcareous falt than from acetated vegetable alkali, and the quantity of inflammable air is much fmaller. This is to be expected from the weaker affinity of calcareous earth than of alkali to oil, and from the greater quantity of acid in the calcareous falt than in the acetated alkali.

In

In the firſt efforts of the fire to decompoſe or tranſmute the acetous acid, the fixable air firſt formed in contact with the lime, adheres to it, and makes mild calcareous earth or whiting, which having a very weak affinity with the phlogiſtic or oily part of acetous acid, makes little or no reſiſtance to its immediate eſcape: wherefore this oily part, having nothing capable of detaining it longer in order to ſubject it to the degree of heat in which it is convertible into in-flammable air, paſſes off by moderate heat in its proper condition, as faſt as the part of acetous acid which forms fixable air is ſe-parated from it.

In the mean time, as much of this latter part as the calcareous earth cannot retain in the degree of heat which it ſuſtains, paſſes off in form of elaſtic fixable air, and mixed with that part of the matter of acetous acid, which having been duly heated before its eſcape, forms inflammable air.

The ſmallneſs of the quantity of inflam-mable air from the acid of acetous calcareous ſalt,

falt, comparatively with that which is pro-
ducible from an equal quantity of the fame
acid detained by fix. veg. alkali, is a ne-
ceffary confequence of the greater quantity
of oil, and fhews that the inflammable air
is furnifhed from the principles of the oil,
and that the quantity of it is greater or lefs
as the heat is, to which thefe principles are
fubjected before they efcape from the bafis
of the acetous falt; all which is conformable
to the refult of thofe experiments in which
inflammable air is made by heat alone from
the oily product of every acetous falt.

Thirdly; The firft effect of encreafing
heat, towards the converfion of acetous acid
into other forms, is to turn a certain part
into fixable air, which having no character
of a phlogiftic body, but all thofe of an
acid, fhews that the part of the acid, which
is turned into fixable air, confifts more of
the acid than of the phlogiftic matter. But
as the remainder of the acetous acid, when
deprived of a great quantity of the acid
principle, forms oil and inflammable air; as
the quantity of oil is greateft when it is

leaft

leaſt heated, and leaſt when moſt heated, or in the greateſt expenditure of it in the formation of inflammable air; we may without heſitation repeat the inductions of the former Sections, with this addition; that whilſt a part of the acetous acid is by the acceſſion of fire formed into fixable air, the remainder, depoſiting the greater part of the water proper to concentrated acetous acid or its ſalts, is diſpoſed to form oil; that the oleaginous matter, when ſufficiently charged with fire, depoſites its water, and forms inflammable air; but in as much as it is forcibly attracted by a fixed baſis, it contributes to the formation of coal.

Fourthly; In the compariſon of theſe experiments we obſerve, that the quantity of fixable air produced from acetous acid is leſs as that of the oil is greater; and from this alone we might expect that the oil, however different from acetous acid, contains a great part of the ſame acid principle which contributes to the formation of fixable air.

That this is at once a true inference and juſt expoſition of the phenomenon, will ap-

pear

pear in fubfequent experiments; and here I fhall only obferve that, in diftillation, we obtain fixable air from this oil in proportion to the quantity of pure air admitted to it, and the degree of heat to which we expofe it: but when the oil, without being ex-pofed much to air, is duly heated, it becomes inflammable air, of which the acid prin-ciple is a conftituent part. The quantity of fixable air, in this cafe, is inconfiderable; the quantity of water is greateft from the firft or colourlefs oil, and leaft from the laft portions diftilled; and the refidue is fo fmall, that we may fay, the oil is wholly convertible into inflammable air, the water and fixable air being variable and ineffential ingredients, which in my prefent ufe of thefe experiments merit no particular attention.

To transform this or any other effential oil into inflammable air, inftead of an iron tube which from its own fubftance yields inflammable air, I ufe a glafs tube her-metically clofed at one end, ftrongly coated with clay, and fitted at the mouth, by grind-ing, to a fmaller bent tube, which forming

F 4

an angle with the large one, may eafily
tranfmit the product of the oil, through
water, into the meafuring veffels. In in-
troducing the oil, I take care that it fhall
touch no part of the tube, except that which
it fills to the heighth of one or two inches;
and then I pour in a mixture of fine white
fand and flint powder, in fufficient quantity
to imbibe the oil. Placing a column of
fand over this charge, to the length of 18
inches or more, I thruft the charged end
into the fand-bed of a reverberatory furnace;
inclining the tube fo, that the fealed end
fhall be nine inches under the fand, the up-
per part of the charge about three, and that
the greater part of the column of fand in
the tube fhall emerge and be fully expofed
to the action of the fire. In this way, the
column of fand is made red-hot before the
charge is heated, and when the fire pene-
trates the fand-bed, or the tube is drawn
forward, the oil which expands flowly from
the flint powder, is forced to pafs through
the winding interftices of the reddened co-
lumn of fand, and iffues through the bent
tube in the form of inflammable air, carry-

5   ing

ing oily vapour, of which the quantity is inconfiderable when the operation is well performed.

The oils which yield a greater quantity of fixable air than can be imputed to what they have imbibed, or that which the air admitted can contribute to form, afford nothing contradictory to the foregoing expofition; for I do not affert that oil may not combine with the principles of fixable air, in confiderable quantity. On the contrary, I have formerly remarked that concentrated acetous acid unites with the oil of acetous falts, and I have no doubt that it may unite with others. But when any oil yields fixable air abundantly, along with the inflammable, I conclude that, like acetous acid, it contained the gravitating principles of fixable air, and not fixable air already formed; for fo innumerable vegetable fubftances contain them; fo mixtures of pure air and this inflammable air contain them, but not fixable air, until they are deflagrated.

Fifthly; Since nothing befides fire is neceffary to the converfion of the drieft oil

producible

producible from acetous acid, into inflammable air, and fixable air in fmall and variable quantity; fince nothing elfe is active in caufing thofe parts of matter, which in the oil were coherent and united, to repel each other and form an elaftic fluid; and fince from the fame oil by the fame fire we produce new compounds, viz. fixable air and inflammable air, between the diffimilar parts of which there is alfo repulfion; we muft in conformity to the general and beft eftablifhed principles of chemical union, conclude that fire combines with fome principles of the oil, with which it forms molecules, which repel each other by virtue of that fire, and conftitute fixable air; that it alfo combines with the phlogiftic part of the oil affociated with a portion of the acid principle, and in this combination forms inflammable air, whofe molecules repel thofe of fixable air by the agency of fire only.

Sixthly; From the experiment in which a folution of calcareous acetous falt, poured on frefh lime, is firft dried, and then reduced to a black fubftance, fimilar to the refidue

residue left in the diftillation of this falt, we perceive that the matter of fire which quick-lime holds in combination, and which it emits on the affufion of water, but without exciting illumination, effects the tranfmutation of acetous acid in the fame manner as fire iffuing luminous from burning fuel; and therefore, that it is the mere matter of fire, and not a particular motion or modification of it, that produces thefe changes in the acetous acid.

Seventhly; The accenfion of the oil produced from acetous acid, by the flame of a candle approached within five or fix inches of it, or indeed by a flame two or three feet diftant from it in deep veffels, although it be a phenomenon common to many oils and ethers, is not to be difregarded.

Of thefe the characteriftic and rareft oily matter owes its palpable form as much to the preffure of the atmofphere, as to the attraction of the molecules of fuch oil to each other: for when that preffure is averted, ethers and the finer oils expand, by a great

part

part or the whole of their matter, into the form of an aerial fluid. During this expanfion cold is produced ; that is to fay, they imbibe and fix the uncombined fire of the fpace through which they expand, and of the contiguous bodies. Thus it appears, that thefe oily bodies attract fire; that in their aerial or vaporous form, they can fix more of it than in their denfe ftate ; and that the powers which limit their union with fire in their ordinary condition, are the attraction of aggregation, and the concurrent preffure of the atmofphere. All which is exemplified in the rapid emiffion of fixable air, or nitrous air, or marine acid, or volatile alkali, from water charged with either of thefe, fo foon as we remove a part of the preffure of the incumbent atmofpheric air.

S E C T.

S E C T.   VI.

Experiments to determine whether the appa-
rent conversion of Acetous Acid is not
owing to the Abstraction of some Principle
of it, as well as to the Accession of Fire.

A L L bodies that contain the acid and
phlogistic principles of acetous acid,
attract air, and by air duly administered,
may be made to furnish salts possessing the
acid character, but differing from each
other according to the proportions in which
these principles are held, and the basis that
holds them in combination. Hence the sac-
charine and other new vegetable acids, which
so far as they consist of the foregoing princi-
ples, are convertible by fire into fixable and
inflammable air, leaving a small residue of
the fixed matter peculiar to each of them.

This is our inference from the processes
for making the new acids, and from all
the experiments for decomposing vegetable
substances

fubftances by fire, from the time of the learned Dr. Hales' to the lateft efforts of the affiduous and ingenious Fontana.

But fince the works of fo many able phi- lofophers tend to imprefs the notion, that the products of fuch proceffes exifted al- ready formed in the fubjects, and that they are only liberated in confequence of the ab- ftraction of the refiduary fixed matter; and fince the like reafoning might be thought applicable to my experiments, and confe- quently to weaken the foregoing inductions; I judged it neceffary to make fome efforts to prove the total converfion of the mere ace- tous acid by fire only, in experiments which the inaccuracies of the foregoing could not affect.

I foon found that a great part of what was done with this view, was applicable to greater ufes, and I now think that, to avoid repetitions, it ought to be referved for a future part of this Effay, as the following experiments feem fully fufficient for our prefent purpofe.

The

The earthen retorts generally uſed in London, are made of the common crucible compoſition, which confiſts of powder of baked clay, made plaſtic with fat apyrous clay and water. Theſe are porous and ſpongy to a great degree, as may be eaſily ſeen by the quantity of water which they imbibe, and for this reaſon alone the pro-ducts of acetous ſalts diſtilled in them, differ in quantity from thoſe which I have de-ſcribed:

The expedition with which operations muſt be conducted in my public courſes of chemiſtry, often required that red-hot earthen retorts ſhould be cooled quickly, in order to ſhew the reſiduary matter from which elaſtic fluids were expelled; and on theſe occaſions I obſerved, that whenever an ounce or more of water was thrown on the reddened veſſel, a conſiderable quantiry of elaſtic fluid, mixed with condenſible wa-tery vapour, iſſued from it. When the water was repeatedly thrown on, until the elaſtic fluid formerly contained in the retort and its lengthened neck were expelled, what

I   followed

followed as the proper aerial product of the
water, or of the matter propelled out of the
pores of the retort, was always found to be
intermediate between atmofpheric and phlo-
gifticated air. At firft I ufed this pheno-
menon to exemplify the porofity and imper-
fection of thefe retorts, and I endeavoured
to explain it thus. The water is drawn by
capillary attraction into the pores at the
furface which it firft touches, and as it
enters thefe, drives before it to the oppofite
or internal furface of the veffel, the air which
had been lodged in them. This air having
been expofed to burning fuel, or meeting
the fuliginous matter which the clay might
have imbibed, is neceffarily more phlogiftic
than that of the atmofphere; and as the
part of the water, which is firft and moft
deeply imbibed, is fooneft and moft heated,
its vapour is determined to expand into the
veffel, by the power which propelled the
air in the fame courfe: to account for the
quantity of air, I had recourfe to the ob-
fervations mentioned in my Effay on Calca-
reous Cements, page 16.

To

To this evident permeability of the common retorts, I attributed the waste of water and other products which always occurred in distilling acetous salts in them, but I could not so easily account for another phenomenon which constantly attended this waste, namely, the extraordinary quantity of phlogisticated air, and the increased proportion of the fixable air, relatively to the quantity of the inflammable.

My conjectures on this subject need not be now related, since Dr. Priestley's experiments, communicated to the Royal Society in 1783, relating to the air produced when porous retorts containing water are thus exposed to heat, serve fully to explain these appearances. I was however fully convinced, that the retorts above described were utterly unfit for my chief purpose in these experiments, and I had recourse to those of a more compact kind, with which I was favoured by my most respectable neighbour, the ingenious Mr. Wedgwood.

With

With thefe retorts, which I wetted on
the outfide with a ftrong folution of borax,
I found the acetous falts could be diftilled,
with very little variation of the products, in
fixable and inflammable air efpecially, from
thofe of the diftillations in glafs veffels; and
the refiduary matter did not fenfibly differ
from what was left in the glafs retorts,
when the degree and duration of the heat
was not greater than they had fuftained.

Having diftilled acetated vegetable alkali
in one of thefe compact retorts, to the point
at which the emiffion of elaftic fluids had
formerly ceafed, and at which the refiduary
mafs was known to confift of vegetable al-
kali, fixable air, and alkaline tinder, in the
proportions already defcribed; in order to
learn what this would yield by mere igni-
tion, I augmented the fire gradually; the
effect of which was to expel the fixable air
of the alkali, mixed with inflammable air of
the fame fpecies with the former, but of a
lighter kind. The quantity of fixable air
was never lefs than $\frac{2}{3}$ of all that I had for-
merly obtained in the faturation of the like

I

alkaline coal with marine acid; and the in-
flammable air bore the like, or rather a
greater proportion to the phlogiftic matter
which was found to refide in the alkaline
tinder.

When the emiffion became very flow,
although the furnace was hot enough to
melt caft iron, I withdrew the fire; and in
the cooled retort I found a folid mafs, taft-
ing alkaline and cauftic, of a reddifh brown
colour, and opaque; and the retort was
manifeftly corroded. The alkali had preyed
upon the filiceous matter, and both thefe
on the argillaceous and magnefian of the
veffel; and I make no doubt that if it had
diffolved more of the fubftance of the re-
tort, it would have emitted more of its
fixable air. This cauftic mafs, compared
with flags made of alkali and Devonfhire
clay, flightly impregnated with charcoal
powder, fhewed clearly that its colour was
owing to the fmall remains of the phlogiftic
matter of the tinder above defcribed; but
that no fubftance decidediy combuftible,
could be feparated from it.

G 2   It

It would be a vain labour to look for any suppofititious fixed matter of the acetous acid in this compound of alkali and earths; and fo far as this experiment approximated the intended purpofe, it fhewed, that the part of the acetous acid, which in fome experiments remains fixed in the folid combuftible fubftance, only requires more heat to be extricated, and to form inflammable air.

With the fame views I made the more fatisfactory experiment following.

I expelled the ufual products from acetous calcareous falt, heated in a Wedgwood retort as much as the coated glafs veffels had formerly been; and when the emiffion had flackened, or almoft ceafed for half an hour; at which time, I knew from former experiments, as well as by direct menfuration of the products, how much calcareous earth, fixable air, and coaly matter, was contained in the retort; I encreafed the heat as in the laft experiment. When no more elaftic fluid could be expelled, I removed the retort out of the furnace, to prevent as much

as poſſible the vitrification of the calcareous
earth.

The quantity of fixable air thus obtained
by the ſecond or ſtrong heat, was nearly the
ſame as was formerly expelled in the ſolu-
tion of the black reſidue of acet. calc. ſalt
diſtilled in a glaſs retort; and allowing for
the rarity of the inflammable air which
iſſued along with the fixable, I found its
weight to correſpond ſo nearly with that of
the matter expelled in the calcination of the
coaly ſubſtance which was ſeparated from
the black reſidue of acet. calc. ſalt, by the
ſolution of the mere calcareous part in ma-
rine acid, that I entertained no doubt of the
total converſion of that matter which with
calcareous earth makes the coal, into in-
flammable air.

On opening the retort, I found a part of
the calcareous reſidue vitrified, as indeed I
expected, where it touched the clay of the
retort; but the upper and central parts, to
which the vitrification did not extend, con-
ſiſted of ſpongy friable calcareous earth,

G 3   preſerving

preferving the figure of the pellets ufed in
the charge, and rather grey and yellow than
white. It was foluble without effervefcence,
excited heat, and flaked on the affufion of
water, and poffeffed every character of pure
lime, except its perfect whitenefs; but this
the beft limeftone never acquires, when it
is reduced to lime in clofe veffels, for with-
out the aid of air, the phlogiftic matter
cannot be totally expelled, or to fpeak in
terms lefs exceptionable to fome philofo-
phers, the white colour cannot be attained.

Here I refted in full perfuafion that the
converfion of the acetous acid does not de-
pend on the abftraction of fixed parts, or
the mere expulfion of the volatile from
them; but that it is effected by the acceffion
of matter which can be no other than fire,
fince none other thus pervades glafs and
porcelain. And now I imagine the reader
perceives more diftinctly, that the fixable air
is formed from acetous acid, fo far as the
gravitating principles of this air, in com-
bining with fire, lofe their former con-
nexion with the other parts of acetous acid;
that

that the remainder of this acid, exclusive of water, either is converted into inflammable air, as faft as the fixable air is formed, or is totally convertible into inflammable air, by a due charge of fire ; that the water of acetous acid, or its falts, is paffive in thefe proceffes, or ineffential to the fixable or inflammable airs ; and finally, that the mere acetous acid contains nothing but the gravitating principles of fixable air and denfe inflammable air, and requires nothing but fire to form thefe elaftic fluids, whofe parts repel each other by reafon of the fire only ; becaufe previous to the decompofition, which is effected by an acceffion, and not by any lofs of matter, they attracted and were coherent. Juft fo, the aerial principle of nitrous acid combines with fire, when a nitrous falt is heated to rednefs, and forms the elaftic fluid called pure air, and eafily depofites the concomitant acid, when this alfo is charged with fire and meets water.

It may not be improper on this occafion to obferve, that in diftilling acetated calcareous falt in a Wedgwood retort, and fuffer-

ing

ing the whole product of condenfed water and ethereal oil to remain in the recipient, until the operation was finifhed, they prefented two liquors, perfectly diftinguifhable, in comparing the upper oily part with the loweft watery fluid, but yet fo far blended where they met each other, as to exhibit a gradation from the oily to the aqueous confiftence. In pouring the whole into a funnel, in order to feparate them, they blended together, and formed a femi-tranfparent liquor, from which not $\frac{1}{10}$ of that which before appeared like oil, was afterwards feparable. This I attributed to the incapacity of the mild calcareous earth to detain the ethereal oil, until by the abftraction of water, it becomes fatter or more concentrated.

S E C T. VII.

*Experiments on Acetated Magnefia fupport-
ing the foregoing Inductions; and Obferva-
tions on Fuel.*

CONCENTRATED acetous acid
has very little effect on magnefia, un-
til water is added in fufficient quantity to
diffolve the falt as faft as it is formed. When
mild magnefia is gradually added to the acid
moderately diluted, to the point of fatura-
tion, the folution has a gluey confiftence,
and retains a much greater quantity of fix-
able air than I have ever obferved to be held
by any other neutral liquor: it alfo retains
this air with greater obftinacy, and fuftains
a boiling heat for fome hours before it parts
with the whole of it.

In boiling it froths to the heighth of a
foot or 18 inches, with bubbles, many of
them exceeding two inches in diameter,
which endure for many minutes, and by
their

their toughnefs and opacity, refemble thin bladders.

This faline liquor taftes like the yeaft of fweet ales, and in my opinion differs very little from it: for in a curfory analyfis, I find yeaft to confift of magnefia, combined with the phlogiftic, acid and watery matter of acetous acid. By evaporation, this liquor becomes as tough as melted glue, and then dries to a femi-tranfparent horn-like fub- ftance, which adheres ftrongly to glafs or porcelain, and is deliquefcent. All this time it exhales acetous acid; and like the calcareous falt, it is found, in its dry ftate, to retain much lefs acetous acid than was neceffary for the folution of the magnefia.

The continual frothing, and the agitation which is neceffary during the evaporation and exficcation of this acetated magnefia, muft promote the abforption of air, if it is difpofed to abforb any; and it is with a view to the effects of this air, and the fpon- taneous efcape of a certain part of the acid from this falt, that I notice thefe particulars.
The

The dry acetated magnesia thus prepared, and diftilled in the manner of the calcareous falt, yielded in the fame circumftances water, oil, fixable and inflammable air. But the quantity of fixable air, in diftillation, was greater relatively to the inflammable; and much lefs fixable air remained in the refiduary magnefia than in the black refidue of the calcareous falt. No acetous acid was ever found in the firft products of the dry magnefian falt; and the matter left in the retort, after the emiffion of air had flackened or ceafed in a red heat, was black, fpongy and friable, fo that it could fcarcely be handled, without falling into powder.

Vitriolic acid, diluted with an equal or any other quantity of water, fhewed no action on this black matter for 30 or 40 feconds; but when the folution became perceptible, it proceeded and increafed rapidly with confiderable heat. Only a fmall quantity of fixable air, fuch as magnefia can retain in a red heat, was emitted during the folution, and a light coaly matter arofe

towards

towards the furface, and remained undif-
folved in the acid liquor.

This vitriolic folution yielded by evapo-
ration Epfom falt only; and the coaly powder,
which refifted frefh vitriolic acid, and
was then wafhed and dried, was found to
vary in quantity, with the intenfity and du-
ration of the heat to which it had been ex-
pofed, and was always combuftible and re-
ducible to magnefia, in confequence of the
expulfion of its phlogiftic matter. This
magnefia contained fixable air when the
combuftion or calcination was flow; but
in the contrary circumftances, it was mere
magnefia indurated by the heat.

In diftillations by moderate heat, the
black refidue refifted the action of vitriolic
acid for the longeft time, where it appeared
to be beft impregnated and defended by the
infoluble coaly matter; but the refidues
which had fuftained greater heats, and
which diffolved flowly, feemed to refift acids
by virtue of their induration or aggregation
3   only.

only. This laſt is a well known property of magneſia indurated by intenſe heat.

In divers variations of my experiments on acetated magneſia, I obſerved the following particulars.

The drieſt ſort yielded more of its acid in the form of fixable air, than any ſuch ſalt leſs dried and leſs expoſed to air; and it afforded the ſmalleſt quantity of water and oil. When a moiſt ſalt was uſed, the firſt portions of water were ſlightly impregnated with acid, and the apparent quantity of oil was greatly augmented, for the true oil blended with a conſiderable quantity of the preceding or concomitant water.

This, like the oils formerly deſcribed, diffuſed itſelf in open air, and by its va-pour catched fire from a lighted candle placed at ſome diſtance. For this, like other volatile oils and ethers, owes its ag-gregation partly to the preſſure of the at-moſphere, which it eſcapes when nothing intercedes them, becauſe it freely pervades the compreſſing column.

When

When the black coaly refidue of the mag-
nefian falt was urged with a very ftrong
heat, it emitted a little fixable air, mixed
with a much greater bulk of inflammable,
and loft proportionably of its weight and
blacknefs, until it became grey, and was
reduced to the quantity, or to lefs than that,
of the mere magnefia originally employed.
In the fierceft heat it vitrified wherever it
touched the earthen retort, and there formed
a glaffy grey or pearl-coloured flag, re-
fembling that of talc.

When the black magnefian coal was
heated to rednefs in contact with pure air,
it entered into combuftion, and formed
fixable air, of which a part was retained in
the magnefia, and the remainder was eafily
feparable from the refiduary pure air.

The quantity of fixable air expelled from
the magnefian falt, relatively to that of the
inflammable, is greateft in the early periods
of the procefs, and gradually decreafes to
the end; for the magnefia can retain but a
fmall quantity of fixable air in a weak red
heat,

heat, but it obſtinately retains the matter which by due ignition forms inflammable air.

By the moſt careful examinations of the different reſidues of divers proceſſes, I could not diſcover any matter depoſited by the products already deſcribed in the magneſia, except the phlogiſtic, which in diſtillation formed inflammable air, and by calcination in contact with pure air, yielded fixable air.

From all this it appears, that any quantity of acetous acid that magneſia can detain, until it is ſufficiently charged with fire, undergoes the tranſmutation already deſcribed, and is totally converted, not by the depoſition of any matter in the magneſia, but by the acceſſion of fire; and the inferences formerly made, are all ſupported by theſe experiments, but need not be repeated here.

It is however expedient now to remark, that the very matter which in combination with fire, or by the mere action of fire,

makes

makes our inflammable air, is ftrongly at-
tracted not only by fixed alkali and lime,
but by magnefia likewife, and with each of
thefe, forms a fpecies of coal or fuel. It
is a fact likewife highly meriting our atten-
tion, that thefe moft foluble fubftances,
whofe appetence of acids is of the ftrongeft
kind, become infoluble in their ordinary
menftrua, by this union with the matter of
our inflammable air, which they thus ap-
pear to attract more powerfully than vitriolic
acid, and which cannot be expelled from
them, except by intenfe heat, or the con-
current action of fire and atmofpheric air.

By thus making artificial fuel, fimilar to
charcoal or coke, and equally infoluble in
acids, although containing alkali or foluble
earths, we are led to the knowledge of the
conftituent parts of native fuels. Thefe yield
our inflammable air by heat, and contain
little more than the gravitating matter of it,
which with pure air yields abundance of
fixable air, in the combuftion of them.
Therefore, if an acid principle is neceffary
to the conftitution of fixable air, it is con-
tained

tained in this inflammable air, and confe-
quently, is united along with the phlogifton
in all thofe bodies which are partially or
almoft totally convertible into this inflam-
mable air by heat, or which in combuftion
yield fixable air abundantly. Thus char-
coal will appear to confift of phlogifton
and the acid principle of acetous acid, toge-
ther with a fmall quantity of fixed vegetable
alkali and calcareous earth; fince $\frac{19}{20}$ or
more of common well burned frefh charcoal
are convertible into that inflammable air :
and our acid principle united with phlo-
gifton, requires very little, if any other
matter, in order to form a body highly
combuftible where fire and air act on it ;
but otherwife durable, refifting acids, and
confiderably fixed in clofe veffels, yet una-
ble even in this circumftance to maintain
its aggregation againft the utmoft force of
fire.

H   S E C T.

SECT. VIII.

Phenomena of Acetous Acid in Mixtures with the Vitriolic, and Observations generalizing the foregoing Inductions.

WHEN acetated vegetable alkali is decompofed by vitriolic acid, previoufly diluted with an equal quantity of water, and cooled, there is very little heat or intumefcence during the mixture ; and if the acetous falt employed for this purpofe is neutral, no fixable or inflammable air appears, and little or nothing iffues, until the charge is heated. In diftillation, the firft portion of acetous acid is ftrong, but the fucceeding are weaker, in regular gradation, until the acid arifes, diluted with fo much water as fcarcely to be equal to diftilled vinegar. The refiduary mafs is vitriolated Tartar, and neither this nor the fides of the retort contiguous to it, fhew any blacknefs or figns of phlogiftic matter.

When

When the acetated falt is decompofed by the moft concentrated vit. acid, and due care is taken, in the manner formerly defcribed, that the heat excited during the mixture fhall not exceed 100 degrees; the acid arifes highly concentrated at firft, but weaker afterwards, and the refiduary vitriolated Tartar appears clean and white.

But when highly concentrated vitriolic acid and the drieft acetated vegetable alkali in powder, are mixed in large quantity, and equal weight, as quickly as is poffible, in earthen ware, a quantity of fixable and in-flammable air is immediately difcharged along with the acetous product, and is always proportionate to the heat excited in the mixture; the produce in acetous acid is at the fame time leffened, and is fuc-ceeded by volatile vitriolic acid in confider-able quantity. If the fire be withdrawn when this volatile acid arifes in thick white fumes, the refiduary vitriolated Tartar with excefs of vitriolic acid is found blackened with coaly or oleaginous matter, and the fides of the retort fhew an oily ftain.

In

In divers experiments of this kind, the acetous acid was expofed to the action of difengaged vitriolic acid, and of the fame diluted with water, and never appeared to fuftain any change from the mere action of that powerful mineral acid. But when great heat was excited, and this fire co-operated, a part of the acetous acid was transformed into fixable and inflammable air, as it would have been by fire any other way adminiftered, whether the vitriolic acid was ufed in excefs, or only in the quantity neceffary for faturating the alkali of the acetous falt; and at the fame time a portion of oily matter was detained in the vitriolated Tartar, or phlogifticated the difengaged part of its acid, as any other oil or as char-coal would do. From all which I inferred that phlogifton is attracted more forcibly by the acid principle of acetous acid than by the vitriolic acid in its ordinary form; that this converfion of acetous acid, in the pre-fence of the vitriolic, is effected, not by this laft, but by the fire emitted during the union of vitriolic acid with the vegetable alkali; and that in confequence of the fe-

I

paration

paration of the matter expended in the
formation of fixable air, the refiduary more
phlogifticated matter of the acetous acid,
forms inflammable air, fo far as it meets
a due quantity of fire, but otherwife pre-
ferves the oily form. A portion of this oil
follows and blends with the acetous acid
which efcapes the decompofition, and the
remainder detained in the refiduary vitriolic
mafs, forms a coaly fubftance, as it does
with divers other bodies, or meeting difen-
gaged vitriolic acid, gives the fame products
as are always obferved in the diftillation of
this acid with oils or charcoal, or any vege-
table or other fubftance which yields fix-
able air in combuftion, and thus appears to
contain the acid as well as the phlogiftic
principle of acetous acid.

To try the validity of thefe inductions,
and the truth of my interpretation of the
phenomena, I made the following experi-
ments.

With 16 ounces of the oil of vitriol of
the manufacturers, I mixed the fame quan-

H 3   tity

tity of concentrated acetous acid, whofe
fpecific gravity fhewed that it contained an
ounce of water beyond the quantity which
the ftrongeft acetous acid ufually holds.

The heat excited was about 200 degrees,
and the mixture in a few hours acquired a
pale ftraw colour. The firft 10 ounces of
acetous acid diftilled from it did not differ
in any thing remarkable from concentrated
acetous acid, and the refidue was tranfpa-
rent, but amber-coloured. Along with the
eleventh ounce, volatile fulphureous acid
iffued, mixed with a very fmall quantity of
inflammable air, and phlogifticated air; but
as the quantity of this laft decreafed very
quickly, it was confidered as the atmof-
pheric air included in the veffels at the
commencement of the operation, the pure
air of which was expended on the charge,
or in the fulphureous acid which imbibes
pure air in the prefence of water. Now
the liquor in the retort became reddifh
brown and opaque, and during the diftil-
lation of another ounce, which was received
apart, the elaftic fluids iffued more copioufly.

Thefe

Thefe confifted of volatile vitriolic acid,
mixed with about $\frac{1}{8}$ part in bulk of fixable
air, and a quantity fcarcely worth notice of
inflammable air. The weight of the elaftic
fluids, acid, water and refiduary matter,
was very little lefs than that of the materials
of the charge and the pure part of the air of
the veffels, and I had no reafon to doubt
that the fmall deficiency was owing to the
watery vapour which was blown away along
with the elaftic fluids. Rejecting the laft
ounce of diftilled acid, becaufe it was chiefly
water, I faved the preceding 11 ounces for
future ufe,

The refiduary acid in the retort was now
of a dark red colour, by tranfmitted light,
where it was made to fpread thinly on the
fides of the veffel ; but the whole mafs by
reflected light looked black, and perfectly
opaque.

I mixed the foregoing 11 ounces of ace-
tous acid with 11 of oil of vitriol, by which
heat was excited as before, to about 200 de-
grees. In diftilling nine ounces of colour-

lefs

lefs acetous acid from the mixture, I ob-
tained the fame products and noticed the
fame phenomena as appeared in the former
procefs. Referving this acid, I proceeded
until another ounce, confifting of weak ace-
tous acid, impregnated with volatile vitri-
olic, was collected, and in the mean time,
the quantity of elaftic fulphureous acid and
fixable air, mixed with a little inflam-
mable air, was encreafed. The bulk of the
fixable air was about $\frac{1}{8}$ of that of the volatile
vitriolic acid as formerly. I then withdrew
the retort from the hot fand, and found the
acid in it to have all the appearances already
defcribed. The weight of this and of the
foregoing products was almoft equal to that
of the acids employed; the deficiency not
exceeding what ought to be allowed for the
watery vapour blown away along with the
elaftic fluids.

The nine ounces of acetous acid laft men-
tioned being diftilled again with the fame
quantity of the moft concentrated vitriolic
acid, prefented the fame phenomena, with
this difference only, that fixable air and
volatile

volatile fulphureous acid and inflammable air were produced in greater proportion, relatively to the acetous acid : and as the acetous product was next diftilled with a double quantity of concentrated vitriolic acid to the fame effect, except that the quantity of elaftic fluids was augmented, I ceafed when the acetous acid was reduced to three ounces, in order to examine it ; being already convinced that the whole of acetous acid by this treatment may be reduced to the forms of fixable and inflammable air, and oil capable of affecting the vitriolic acid like other oils and combuftible fubftances.

Thefe three ounces of acetous acid, combined with fixed vegetable alkali, made a fine white foliated falt, as purified acetous acid would do. And this falt in diftillation yielded water, oil, fixable air, inflammable air, and a black coaly refidue in the proportions formerly defcribed in the diftillation of acetated vegetable alkali ; and the coaly alkaline refidue in like manner yielded fixable air, and the black combuftible fubftance refembling lamp-black.

The

The feveral portions of vitriolic acid,
which was thickened and rendered opaque
in thefe diftillations, were mixed and diftil-
led, and the condenfible product was faved
in three feparate and equal parts. The firft
confifted of oil of vitriol, weakened with
about two ounces of water, and impreg-
nated with fulphureous acid, and during the
diftillation of this part, a great quantity of
volatile vitriolic acid, mixed with $\frac{1}{13}$ of its
bulk of fixable air, was emitted.

The fecond portion was oil of vitriol,
fmelling of fulphureous acid, but clear and
colourlefs, and along with this iffued elaftic
fulphureous acid, mixed with much lefs
fixable air than was in the former; the third
portion was like the fecond, but was not
accompanied with fo much volatile ful-
phureous acid : and in the retort I found
fix ounces of a dark red opaque liquor, of
the confiftence of treacle, whilft hot, but
which concreted in cooling into a wet faline
mafs, fuch as might be expected from oil
of vitriol, ftained by oil, and imbibed by a
falt irregularly cryftalized. I afterwards
found

found that this was nothing more than the vitriolated Tartar, Selenite and Epſom ſalt, which accompany all the oil of vitriol of the modern manufactories, impregnated with the oleaginous matter of the acetous acid, which every body hitherto tried appears to retain, until it is violently heated or calcined in contact with air.

In all this we ſee nothing like a dephlogiſtication or decompoſition of the acetous acid by the vitriolic. On the contrary, the acetous acid which ariſes by moderate heat from the vitriolic, ſuffers no change; but that quantity of it which can be detained in vitriolic acid, until it ſuſtains greater heat, undergoes the very ſame tranſmutation that fire alone always produces, whatever the ſubſtance may be that fixes the acetous acid.

We now well know the reaſon why ſome part of the decompoſed acetous acid became fixable air; why in the moderate heat very little appeared as inflammable air, and much more aſſumed the oily form; and if the queſtion,

queſtion, implying ſome fallacy in this
reaſoning, were propoſed, viz. why does
the vitriolic acid become phlogiſticated? I
ſhould anſwer firſt, the vitriolic acid be-
comes volatile or phlogiſticated in diſtillation
with any of the ſubſtances which yield ſuch
inflammable air by heat as the oil of acetous
acid affords: all oils and- vegetable ſub-
ſtances, not excepting the drieſt, or the
charred coal of them, have this effect with
vitriolic acid: in other and more general
terms, all bodies that contain the ſame
phlogiſtic and acid principles that reſide in
acetous acid, render vitriolic acid volatile in
diſtillation : and ſecondly, without affecting
the validity of this anſwer, founded on
known facts, I ſhould ſay that in all the
phlogiſtications of vitriolic acid that I ever
ſaw, pure air is withdrawn from it : and as
in the inſtance before us, the oleaginous
part of the acetous acid forms fixable air,
whilſt the vitriolic acid becomes volatile,
and pure air would alſo form fixable air with
the ſame oleaginous matter thus heated ; I
conclude that pure air is more forcibly at-
tracted by this laſt than by the acid prin-
ciple

ciple of ignited vitriolic acid, and confe-
quently that this acid, by the fubduction of
the pure air, and the fubftitution of phlogifton
from the oleaginous matter, makes volatile
fulphureous acid. This is fufficient for the
prefent occafion; for it would lead me too
far from the objects of this Effay, to enu-
merate the experiments by which I have
been induced to believe that volatile vitriolic
acid confifts of the vitriolic acid principle
combined with phlogifton and fire, whilft
the ordinary vitriolic acid is compofed of
the fame acid principle, pure air and water,
with lefs of the matter of fire.

The phenomena of thefe experiments on
mixtures of acetous and vitriolic acid, im-
preffed me with fome doubts, which I have
not introduced in the relation, becaufe fuch
meafures only ferve to perplex the reader,
in exhibiting the fagacity of the experi-
menter. To remove thefe fcruples, and
look for fomething further, I varied the
experiments in the following manner.

I mixed 24 ounces of ftrongeft acetous
acid with 48 of my ftrongeft oil of vitriol.
The

The mixture became hot as in the former experiments, and in a few hours had a light ftraw-colour. In diftilling 13 ounces of clear colourlefs acetous acid from it, the quantity of elaftic fluid emitted was not confiderable; after the thirteenth ounce, the acid diftilled grew gradually and uniformly weaker, and the emiffion of elaftic fluids encreafed.

The next feven ounces confifted of acetous acid and about an equal quantity of water confiderably impregnated with vitriolic and volatile vitriolic acid; and the next 17 ounces confifted chiefly of vitriolic acid mixed with water and a little volatile vitriolic acid; and during the diftillation of thefe, volatile vitriolic acid in the elaftic form iffued in confiderable quantity, mixed with fixable air and a little inflammable air. The bulk of the fixable air was, as formerly, about $\frac{1}{8}$ of the inflammable.

As the acid laft diftilled at this period, was as ftrong as oil of vitriol, I removed the veffels from the fire. The matter remaining

maining in the retort was opaque, and of
the confiftence of fyrup, when cold, and
looked black in the mafs; but where it was
made to fpread thin on the retort, it looked
femi-tranfparent and of a livid red colour.

Rejecting the portions of acid laft diftil-
led, becaufe they were diluted with the wa-
ter which appertained formerly to the part
of the acetous acid that was thus decom-
pofed, and with the water which was form-
ed, as will be fully fhewn hereafter, by the
union of the mere phlogifton of acetous
acid with the pure air of the vitriolic, I
took the 13 ounces of acetous acid firft
drawn off, and mixing them with the livid
vitriolic refidue in the retort, proceeded to
diftillation. The heat excited during the
mixture was not, to my feeling, fo great as
before, and very little of any elaftic fluid
iffued from the charge, until about nine
ounces were diftilled; but in drawing off
the tenth ounce, volatile vitriolic acid iffued
copioufly and mixed with about $\frac{1}{4}$ of its
bulk of fixable air and a little more in-

I   flammable

flammable air than had appeared in former experiments.

The diftillation was continued, with the fame phenomena, until the matter in the retort was reduced to 24 ounces; and the product, collected after the nine ounces of acetous acid, confifted of vitriolic acid much weakened with water, and flightly impregnated with acetous and volatile vitriolic acid.

Now one purpofe of this trial was accomplifhed; for acetous acid, weighing 13 ounces, and which had been previoufly expofed to the action of 48 ounces of concentrated vitriolic acid, was as much decompofed in the mixture with the blackened refiduary vitriolic acid of the former diftillation, as ever the acetous acid had been by an equal quantity of frefh vitriolic acid; and thus the decompofition appeared to have been effected by fire, and not by the vitriolic acid, except fo far as it ferved to detain the acetous acid. The furplus of inflammable air which appeared above the

quantities

quantities noticed in former diſtillations, was owing to nothing more than the incapacity of the blackened oil of vitriol to furniſh ſo much atmoſpheric air as is contained in the pure and colourleſs; for the ſame matter which yields inflammable air, always affords fixable air when under due ignition it meets pure air.

The nine ounces of acetous acid firſt drawn off in the foregoing diſtillation, appeared on divers trials to be acetous acid unaltered in every reſpect, except that it was impregnated with a little of the vitriolic, and contained more water than is proper to our concentrated acetous acid: for in mixture and diſtillation with freſh concentrated oil of vitriol, it preſented the phenomena deſcribed in the beginning of this Section; and the portion of it that was diſtilled unaltered in this proceſs, being divided into two parts; one of them combined with calx of lead and diſtilled, gave the ſame products as are obtainable from the like calx combined with my pure acetous acid; and the other part, combined

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with fixed vegetable alkali, made acetated vegetable alkali, which yielded water, oil, fixable and inflammable air, and a black alkaline coal, like thofe of pure acetated vegetable alkali : and in thefe trials the vitriolic impregnation was found to be fo fmall as fcarcely to deferve any notice.

Wifhing to know the condition of the matter that gave the blacknefs and fpiffitude to the vitriolic acid remaining in the retort, and which, as I have already fhewn, would be expended, if the diftillation were continued, in the production of volatile vitriolic acid and fixable air; I diluted the 24 ounces of this acid with 16 of diftilled water. In fo doing, I obferved the fame hiffing, heat, and pungent vapour as occur in mixing water with concentrated colourlefs vitriolic acid. But the diluted acid remained opaque, and the opacity was plainly owing to large particles of black flacculent matter, which were diffufed through it, and were not difpofed to feparate by fubfidence, or by rifing to the furface : in order therefore to effect a feparation, by making

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the diluted acid pafs through a filter with-
out corroding it, I added a quart more of
water.

The filtrated liquor fhewed a pale yellow
colour, and when reduced to eight ounces,
or lefs, by evaporation in the open air, be-
came opaque and livid, as if a part of the
oleaginous matter had paffed along with the
acid and water, through the filtering pa-
pers : it alfo depofited fome faline matter,
but this was only what originally was con-
tained in the oil of vitriol employed. The
matter left on the filter was like lamp-black
wetted with weak vitriolic acid, and felt
as if it were in a ftate intermediate between
oil and coal. A fmall portion of it expofed
to heat, firft exhaled water and vitriolic
acid, then became red, and entered into
combuftion, but without any appearance of
flame. By the refidue it appeared to con-
tain fome falts of the vitriolic acid which
might be wafhed away from it. I therefore
wafhed the mafs left on the filter with a
quart of water, which being ufed in fuc-

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ceſſive portions, left the black matter free
from vitriolic acid, or at leaſt inſipid.

The water thus employed being evapo-
rated to an ounce, left about half this quan-
tity of vitriolic acid, which was blackened
by the oily matter that followed it through
the filter conſiſting of good paper in four
folds, and in cooling depoſited ſome ſalt of
the ſame kind with that laſt mentioned.

I had often before obſerved, that the
black reſidues of acetous ſalts impregnated
the water with which they were waſhed, ſo
far that in evaporation the laſt portions of
it appeared turbid and black ; and I attri-
buted this to the imperfection of the filters ;
but in theſe laſt experiments, and others
which they ſuggeſted to me, I found that
the coaly matter, left in the reſidue of di-
vers acetous ſalts decompoſed by heat, is
in a ſmall degree ſoluble in water, like ſe-
lenite or lime, and ſtill more when the water
is acidulated.

The

The black coaly matter that remained on the filter after the ablutions above mentioned, when dried to the confiftence of foap, blackened and ftrongly adhered to every fubftance on which it was rubbed, and neither alkalies nor any of the mineral acids could efface the traces made with it, but aqua regia feemed to weaken them. It floated in a mixture of equal parts of oil of vitriol and water, but was not diffolved by this, or nitrous, or marine acid; aqua regia feemed to alter the colour of it fuperficially, but did not act as a folvent. Its weight was three ounces, of which about $\frac{3}{4}$ were water, which exhaled in drying it to 15 dwts. with a pleafant acid fmell, towards the conclufion.

When it was well dried, it refembled Indian ink in the cake, both in the colour and texture as well as in the traces made with it. When it was further heated, the fmell was not difagreeable; it contracted to $\frac{1}{4}$ of its bulk before it catched fire; and this did not happen until it was heated to rednefs in the open air: then it flamed in

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an inftant, and glowed with a bright red
heat; but in the next inftant, the flame,
which was thin and fmall, difappeared.
On withdrawing it from the fire, the red-
nefs and combuftion fuddenly ceafed, as it
happens to culm and other bodies which
require great heat and ventilation for their
combuftion. It took two hours calcination,
and free expofure to air by frequent agi-
tation, to deprive it of the ccaly character,
and to reduce it to a grey incombuftible
powder, which weighed 48 grains, and by
divers trials confifted of magnefian earth.

From the facts related in this and the
foregoing Sections, it appears that acetous
acid is decompofed in vitriolic acid, in
quantity proportionate to the capacity of
the vitriolic acid to retain it until it fuftains
the heat which alone is neceffary for the
decompofition of acetous acid. That this
capacity of vitriolic acid to retain the ace-
tous is as the relative quantity of the for-
mer, and depends on a general law. For
fo vitriolic acid retains water in a degree of
heat much greater than water alone can
abide,

abide, under the same atmospheric pressure;
so all bodies, from which any thing can be
expelled by fire, retain the last portions of
the volatile matter more obstinately than
the first, and compel them to sustain the
greater heat. It also appears that when ace-
tous acid is decomposed by fire, in the
freest exposure to vitriolic acid, the matter
which is capable of forming inflammable
air, and which consists, as will fully be
shewn in the sequel, of the phlogiston
united with some of the acid principle of
acetous acid; unites with magnesian earth
in preference to the vitriolic acid, and forms
with it a coaly mass, which may in the
common sense of this word be said to be
insoluble. Having in former experiments
seen magnesia containing only a little of this
matter, and perfectly soluble, save only the
parts strongly impregnated with it; and
now finding that one part of mere magnesia
can retain 20, if not any quantity of it, and
that the substance thus formed is of the fixed,
rather than of the very volatile kind, we
readily conceive how this same matter forms
such a variety as occurs in nature of com-

buſtible

buftible bodies, according to the kind and quantity of other matter with which it is combined in them ; and why all fuch bodies, whether fpirits, ethers, oils, gums, refins, vegetable extracts and falts, wood, charcoal, mineral fuel, coke, or fubftances referable to thefe heads, yield fixable air in combuftion, and by due ignition in clofe veffels, denfe inflammable air, which likewife yields fixable air in combuftion : and alfo why fixable air is always produced in the phlogiftication of vitriolic acid by the oleaginous part of acetous acid, or by any vegetable, animal or mineral fubftance, containing the acid and phlogiftic principles of acetous acid, and capable of yielding our denfe inflammable air.

In former experiments, the quantity of water that blended with the oil, or was wafted away with the elaftic fluids generated from acetous acid by fire, was variable; and there was room for doubting whether the water proper to concentrated acetous acid or its falts, was all depofited during the converfion of the mere acid, or

did

did not contribute to the fixable and inflam-
mable air : but in thefe experiments with
vitriolic acid, wherein the quantity of wa-
ter left by the decompofed acetous acid
could be meafured by the fpecific gravity of
the acids diftilled compared with that of
thefe acids in the concentrated ftate in which
they were mixed; I was fully perfuaded
that the acetous acid depofites its water,
previous to the converfion into fixable and
inflammable air, or into that compound
which with divers bodies forms coal ; and
that water is not a neceffary ingredient in
any one of thofe. But I do not infift on
this fubject at prefent, becaufe fuch men-
furation would appear exceptionable, not
only by reafon of the errors to which it is
liable, but becaufe it fhews a quantity of
water which could not, confiftently with
my former experiments, exift in the con-
centrated acetous acid. The caufe of this
phenomenon will be confidered hereafter.

In the laft mentioned diftillation of ace-
tous from vitriolic acid, I was amufed with
a phenomenon which brought to my recol-
lection

lection fome appearances of the fame kind
which I had noticed on former occafions.
When the quantity of acetous acid amount-
ed to about three ounces, and rofe in the
receiver fo high that the diftance between
its furface and the nozel of the long flender
neck of the retort, did not exceed a quarter
of an inch, and when the drops fell at
the interval of three or four feconds, each of
them, rebounding after the fall, and ftill
preferving the globular form, rolled on the
acid liquor ; and then, after floating in a
quiefcent ftate, for five or fix feconds, burft
fuddenly and fpread upon it. Some of thefe
globules in their motion ftruck the preceding
ones, and frequently the motion was com-
municated without either of them burfting
for fome feconds after they became quief-
cent.

Afterwards, when the acid in the receiver
rofe, and was not diftant from the nozel of
the retort by more than the diameter of a
large drop, the liquor which trickled down,
did not difcharge itfelf into the acid, either
in the foregoing manner, or in that of a co-
lumn ;

lumn; but it formed globules of fix times the former bulk; each of which, preferving its proper form, funk by half its diameter into the acid liquor, without mixing with it; but when the fize of any globule encreafed to exceed $\frac{2}{10}$ of an inch in diameter, it then parted from the nozel and fpread on the liquor.

All this looked as if each drop carried its proper atmofphere of repellent matter, which it retained for a confiderable time, with a force greatly fuperior to the weight of a grain, for the drop could not, by reafon of its mere aggregation, rebound from liquor of the fame kind, and roll on it, and dip and fwell in it without mixing.

I immediately attempted to produce the like phenomena in diftilling water, under the fame circumftances precifely; but without fuccefs; neither could I find them in treating fpirit of wine in the fame way.

Upon a review of all the phenomena of this kind that I had ever noticed, I am perfuaded that the drops of all inelaftic fluids

carry

carry their refpective atmofpheres of fome repellent matter which is of the fiery kind; and that in moft fluids, the denfity of thefe atmofpheres is rarely fufficient to refift the approximation or union of the drops with fuch force as to exhibit the appearances above defcribed: but that bodies, whofe principles feverally attract fire fo forcibly as to form elaftic fluids with it, maintain denfer atmofpheres of this matter around their parts or drops, which then repel with greater force; and that the effect of this repulfion is greateft and moft durable, when the drops carry with them any elaftic fluid, exceeding the quantity which they can retain when cooled. The electricity producible in diftillations and evaporations, and the quick evaporation, if not the convertibility of water into an aerial fluid, by the electric matter, are things not repugnant to this notion; which I mention only for its confonance with the agency of fire that occurs in all our experiments.

The mixed elaftic fluids lately defcribed were feparated and meafured in the following manner.

Receiving

Receiving the fucceffive portions through quickfilver, in cylindrical graduated glafs tubes of known capacity, I noted the fpace occupied by each of them, when the mercury within the tube was level with that in the bafon in which the tube ftood. I then transferred the tube into ftrong lime water, and admitted as much of it as could, with the affiftance of agitation, be employed in abforbing all the volatile vitriolic acid without becoming turbid. Guided by fome trials of known mixtures, and contenting myfelf with an approximation to accurate meafurement, I ftated half the bulk of the water fo admitted to be equal to the whole of the volatile vitriolic acid, efpecially when there was a refidue of fixable air; for the water thus impregnated with fulphureous felenite and acid, did not in thefe circumftances appear to imbibe more than half its bulk of fixable air. By wafhing the remaining elaftic fluid in lime liquor, I faw the quantity of refiduary air or inflammable air; and deducting the bulk of this and of the volatile vitriolic acid from that of the mixed elaftic fluids, I found the meafure of the fixable air.

At

At intervals, I received the mixed elaſtic fluids in a veſſel containing a column of water above the quickſilver ; and as the water in this circumſtance imbibed a great quantity of volatile vitriolic acid, and retained little or no fixable air when fully ſaturated with the acid, the bulk of fixable air emitted in a certain time, was ſeen ; and in comparing this with the meaſure of mixed elaſtic fluids which were expelled in the like time of uniform diſtillation, I approximated the true proportions of the different elaſtic fluids ; but not before I had treated the fixable air with lime water in the foregoing manner, in order to ſeparate the volatile vitriolic acid which it carried with it through the column of water, at the period of ſaturation : Then the fixable air was eaſily withdrawn from the inflammable, with which it was generally impregnated.

S E C T.   IX.

Experiments on Mixtures of Acetous and Nitrous Acid.

TO any man that confiders the varieties in fmell, tafte, medicinal effect and technical ufe of the fubftances, whofe products, by the fole action of fire, differ in little or nothing except the proportion of them to each other, as appears in the works of Geoffroy, Hales, Newman, Cartheufer, Fontana and others; it is manifeft, that our knowledge of the principles of vegetable fubftances and of bodies which refemble them in compofition, has been remarkably defective: and the experiments which throw new light on a fubject fo extenfive in nature, and fo interefting to medical practitioners, as well as to divers artifts, muft appear highly important.

With thefe impreffions I undertook many experiments which the avowed purpofes of

this

this Essay did not seem to require; but of which I think a few ought to be related as follows, in order to shew their conformity with the foregoing doctrines, and to generalize the inductions which seem to demand our chief attention.

To four ounces of acetated vegetable alkali I added gradually eight ounces of the strongest nitrous acid; for as strong nitrous acid excites considerable heat in mixing it with water only, and the acetous salt always retains some water, the sudden mixture of the nitrous acid with the acetous salt would from this cause alone, cause a degree of heat sufficient to expel some of the acetous acid.

Notwithstanding this precaution, the heat amounted to about 150 degrees, and some nitrous air and vapour was emitted, but the quantity did not much exceed what might be expelled from the same nitrous acid by heating it. In distillation I obtained eight ounces of acid; of which the four first were chiefly acetous and the rest nitrous acid. The colour of the mixed acids was yellower than

than that of the nitrous acid ufed, and re-
fembled that of nitrous acid flightly phlo-
gifticated. The dry mafs in the retort
weighed about four ounces, was perfectly
white, diffolved and cryftalized like nitre,
and in divers trials was found to be true
nitre, with excefs of nitrous acid.

As the quantity of nitrous acid was twice
greater than what was neceffary for the de-
compofition of the acetated falt; and as the
acetous acid, in the inftant of its expulfion
from the alkali, was fully expofed to an
equal quantity of ftrongeft nitrous acid, and
thefe acids were expofed in vapour to each
other, it was imagined that fome change
might be produced in the acetous by virtue
of the attraction of its phlogifton to the air
of the nitrous acid, and that the nitrous
acid, thus deprived of its air in the prefence
of phlogiftic matter, would form nitrous
air.

But fince the quantity of acetous acid was
as great as the acetated falt can be made to
yield in any decompofition, and the quan-

K   tity

tity of nitrous air or vapour was too fmall
to be imputed to any other agency than that
of the fire, by which alone the nitrous acid
would yield as much as appeared in this
experiment; and as the refiduary falt, con-
fifting of half the nitrous acid combined
with the vegetable alkali of the acetous falt,
fhewed nothing phlogiftic or oleaginous;
it appeared that the acetous acid, which can
fo eafily be decompofed by heat, undergoes
no fuch change in the fulleft and moft ad-
vantageous expofure to the ftrongeft nitrous
acid.

To be more fully affured of this I diftilled
the nitrous acid of the foregoing procefs,
with four ounces of acetated vegetable al-
kali, and obtained the whole of the acetous
acid quite clear and colourlefs : the matter
in the retort was white, and confifted of true
nitre fuper-faturated with nitrous acid only.
Thus the nitrous acid was found to have
undergone no material alteration or lofs;
and the acetous acid, being afterwards tried
in divers combinations, and laftly by fire,
fhewed no appearance of dephlogiftication

or

or decompofition by the action of the nitrous acid.

With the views already expreffed, I mixed eight ounces of acetated lime with the fame quantity of ftrong nitrous acid, and after drawing off the acetous acid and fo much of the nitrous as was ufed in excefs, I diftilled thefe with four ounces of the acetous calcareous falt. The phenomena were fuch as may be expected by any perfon acquainted with the foregoing experiment, and gave no indication of material alteration in the nitrous acid, or of any decompofition of the acetous by the mere action of the former. A fmall portion, indeed, of nitrous and fixable air appeared ; but from the quantity of it, and the period of the diftillation, in which it was produced, it was manifeftly owing to the heat which the charge fuftained at the bottom of the retort, where it had clotted, and was moft expofed to the fire, after the chief part of the liquid matter had been expelled.

I then wetted 16 ounces of dried and pure nitre in powder, with four ounces of

ftrongeft

ftrongeft acetous acid, and added eight ounces of the ftrongeft oil of vitriol, in a glafs retort. The phenomena attending the mixture did not differ in any thing remarkable from thofe which accompany the mixture of fuch oil of vitriol with dry nitre, except that the vapour which iffued was mixed with perhaps a little more nitrous air.

In diftilling four ounces of acid liquor from the charge, about $\frac{2}{3}$ of the common air of the veffels iffued, and carried with them about an equal bulk of nitrous vapour, mixed with a quantity of fixable air, too fmall to deferve particular notice. The condenfed liquor confifted of acetous and nitrous acid, and had a high orange colour. After the fourth ounce, the fubfequent acid fell in a flender column, almoft as fine as horfe-hair, from the nozzel of the retort, through the liquor in the recipient which it touched, to the bottom of it; fhewing this product to be chiefly nitrous acid; and this laft gradually diluted the colour of the firft four ounces of acid until it became yellow.

When

When the whole of the diſtilled acids amounted to five ounces, and acetous acid no longer iſſued along with the nitrous, from the charge, the nitrous acid next diſtilled was green, as phlogiſticated nitrous acid mixed with water always is; and an elaſtic fluid began to iſſue in notable quantity. This conſiſted of four parts in bulk of de-phlogiſticated air, mixed with one of nitrous vapour and nitrous air. But this is the proper produce of that part of the nitre which was conſiderably heated without meeting vitriolic acid in ſufficient quantity to detach its acid in the ordinary ſtate of nitrous acid. For ſome time afterwards, the proportions of dephlogiſticated air and nitrous vapour varied as the heat extended higher in the charge; and as no phenomenon occurred except what is proper to nitre and vitriolic acid ſtrongly heated in theſe pro-portions, I put an end to the operation.

The mixed acids thus obtained were kept ſix months in a cloſe veſſel, and diſtilled by a gentle heat. The portion firſt condenſed to the amount of two ounces was orange-

K 3   coloured,

coloured, and confifted of acetous acid, im-
pregnated with nitrous acid and nitrous
phlogiftic vapour, which made it look ra-
ther opaque, and inclining to olive-colour ;
but by the fucceeding portions of acid, it
was diluted to its former yellow colour, and
the whole paffed over, the laft portions be-
ing entirely nitrous, without leaving a ftain
behind. About half a pint of elaftic fluid
in the mean time iffued from the recipient
through quickfilver, and confifted of phlo-
gifticated air and nitrous air, mixed with
that of the veffels, the bulk of which laft
is not included in the half-pint. This quan-
tity is too fmall to denote any notable change
of the acids in the diftillation, for the mixed
acids could retain fo much nitrous elaftic
fluid from the former procefs, and the
phlogiftication of the air of the veffels, is the
well known refult of the abforption of its
dephlogifticated part by the nitrous air or
vapour.

In this experiment the acetous acid was
firft expofed to the action of the vitriolic
in its moft concentrated ftate ; and when
this

this was expended in decompofing the nitre, it was expofed to the ftrongeft nitrous acid in fubftance and in vapour; and as the diftillation advanced, a part of the acetous acid was expofed at once to nitrous acid in hot vapour, and to the pure air of that part of the nitre, which by reafon of the deficiency of vitriolic acid, and its vicinity to the hotteft part of the fand, was decompofed by heat alone: and as no more of the acetous acid was decompofed or expended in making the nitrous acid red and elaftic, than appears always to be when it is retained in fuch heat; we may truly infer that the acetous acid cannot be decompofed by the mere action of the nitrous, and that in the prefence of the water which is a conftituent part of thefe acids in their ordinary condition, the nitrous acid cannot draw the phlogifton from the acetous, fo as to exhibit it in a dephlogifticated ftate.

As water weakens the action of divers bodies on each other, and efpecially that of acids on inflammable liquors, I had reafon thus to impute the inactivity of the nitrous

acid

acid in thefe diftillations, to the water in-
feparable from both acids in their ordinary
form; but in order to try the validity of
this notion, I made divers experiments with
the ftrongeft nitrous acid and the moft de-
phlegmated oil diftilled from acetated vege-
table alkali: for feeing that acetous acid
may be refolved by fire into fixable air, wa-
ter and oil; that the two former are not
affected by nitrous acid fo as to afford new
compounds, and that the latter is; I con-
fidered this as the only part of the acetous
acid on which the nitrous is apt to act, and
the moft likely to indicate the effects which
nitrous acid would produce with the acetous,
if it could be procured quite free from
water.

The refult of the mixture of thefe was,
that when the oil was flowly added to the
nitrous acid, and gradually blended with it
by agitation in iced water, fo that no fen-
fible heat was excited, they mingled freely
and perfectly, without emitting or exhaling
any thing confiderable, except what they
feverally exhale into the air included with

3   them,

them, previous to any mixture of this kind. The firft drops of oil gave the nitrous acid a yellow colour, the next orange; with more it acquired a claret colour, which grew deeper and darker as the quantity of oil encreafed. The acid neverthelefs feemed to have truly diffolved its bulk of the oil, for in a column of a quarter of an inch in diameter, the mixture appeared uniform and tranfparent. When it was removed from the iced water, and acquired the temperature of the air, which was 36° at this time, it began to difcharge bubbles, which arofe very fmall from the bottom, and grew larger in their progrefs upwards through the liquor, as it happens in making nitrous ether; and in the courfe of twelve hours, a quantity of elaftic fluid was emitted, meafuring upwards of thirty times the bulk of the mixture. Three - fourths in volume of this elaftic fluid were fixable air, and the remainder was inflammable air mixed with nitrous air, the former of which feemed to be nothing more than the proper exhalation of that part of the oil which had efcaped the action of the nitrous acid, or which

having

having depofited its water in the acid, af-
fumed this form, as the ethereal part of
alkohol is difpofed to do in thefe circum-
ftances.

On the application of heat, the mixture
emitted a great deal more of the like elaftic
fluids ; and when phlogifticated nitrous va-
pour arofe in confiderable quantity, I with-
drew the fire, knowing from other expe-
riments what the fubfequent product would
be, and fatisfied already in this proof, that
the nitrous acid needs no heat beyond 36 de-
grees in order to act forcibly on this oil.

When the acid and oil were quickly
mixed in any order, or in any quantity ex-
ceeding a dram of either, the heat and in-
tumefcence were very great, and the quan-
tity of elaftic fluid fuddenly emitted was
proportionate to thefe directly. After it
had depofited the condenfible phlogifticated
nitrous vapour which iffued along with it
from the boiling mixture, it was found to
confift chiefly of fixable and inflammable air
mixed with nitrous and phlogifticated air ;

3   but

but the proportions of thefe varied in dif-
ferent experiments with the circumftances
of them. By attending to thefe, I perceived
that the inflammable air was produced from
the volatile oil which had received the heat
of the mixture, but efcaped the action of
the acid, and that the quantity of fixable
air was directly proportionate to the phlo-
giftication of the nitrous acid. Therefore
this acid and our oily matter mutually de-
compofe each other, and form new com-
pounds, by virtue of the elective attractions
of their principles, and without the aid of
extraneous fire; and as a great quantity of
fire is emitted during the action of the oil
and acid on each other, the quantity of it
that exifts concentrated and combined in
thefe, is much greater than can be retained
in their new products.

In metallic folutions, and in all others,
in which the nitrous acid is phlogifticated;
in all combuftions of phlogiftic bodies,
in which nitrous acid or nitrous falts, by
virtue of the air contained in them, per-
form the office of the pure part of atmof-
pheric

pheric air in calcining, deflagrating or de-
tonating thefe fubftances ; and in every
known inftance of the phlogiftication of
nitrous acid, and of the formation of nitrous
air from it ; the acid principle lofes a part
or the whole of its pure air, and by re-
ceiving phlogifton inftead of it, becomes
nitrous air. The quantity of difengaged
nitrous air that appears in any of thefe cafes
depends on the capacity of the materials
employed, to retain the pure air of the ni-
trous acid in preference to the nitrous air,
and in thefe the confequent predominance
of pure air may eafily be found : hence the
nitrated calces of metals yield abundance of
pure air and little or no acid, as Mr. Ca-
vendifh has well fhewn in the inftance of
Mercurius corrofivus ruber. Of all the ex-
periments which clearly evince this depo-
fition of pure air by the nitrous acid, when
it becomes phlogifticated, and forms nitrous
air, we need only to mention the following.

Nitrous air, whether procured in deto-
nation, in the folution of metals, vegetables,
or other phlogiftic fubftances, or in the
<div align="right">action</div>

action of the nitrous acid and oils on each other, on the admixture of pure air becomes nitrous acid somewhat phlogisticated; and a great part of the pure air thus administered, is actually expended in the formation of the acid, whilst the remainder contributes to the formation of water. In this as well as every other instance of the entry of pure air into a phlogistic body, heat is generated or fire is emitted, shewing that the nitrous air and pure air severally, are capable of holding more fire, than the nitrous acid and water, which they form, can retain.

Aided by these general observations, we may interpret the phenomena of the mixtures of nitrous acid and oil in the following manner.

Whilst the phlogiston of the oil unites with the acid principle of the nitrous acid, the pure air of the latter is transferred to the vegetable acid principle of the oil, and contributes towards the acid characters, which then become as apparent in the fixable air, as the privation of them is manifest

in

in the nitrous air. That this expofition is true will appear from thefe confiderations ; that the nitrous air thus formed, requires only pure air to become nitrous acid, and that difengaged pure air, however procured, together with this oil, in the act of com-buftion in clofe veffels, yield fixable air and water, and nothing elfe, except that quantity of the fire formerly combined in the oil and pure air, which the fixable air and water cannot retain: for I purpofely reject from our prefent confideration a fmall and variable quantity of the elaftic fluid called phlogifticated air, which always appears in the above-mentioned proceffes, and fhall be noticed in due time.

SECT.

S E C T.   X.

*Experiments and Obſervations relating to the
Principles of Acetous Acid and Fixable Air,
and the Bodies from which Fixable Air is
not only extricated but formed; with ge-
neral Interpretations of divers intereſting
Phenomena.*

IN addition to the curſory obſervations
formerly made, I am now briefly to
relate the general reſult of the experiments
which exhibit the agency of air on acetous
compounds.

Having tried every one of the tinder like
and coaly ſubſtances heretofore deſcribed as
conſiſting of oily matter of acetous acid fixed
by earth or alkali or neutral ſalts, by cal-
cining or burning them in contact with pure
air; I found the quantity of fixable air pro-
duced in theſe proceſſes to bear a direct pro-
portion to that of the pure air expended in
them reſpectively. In burning the oils of
acetous acid with pure air from nitre, the
product

product was fixable air and water, exclufive of the fire emitted and a fmall and variable quantity of phlogifticated air; and when the oils containing the fmalleft quantity of water were ufed, the weight of the fixable air equalled or exceeded that of the oil. In burning the inflammable air expelled from acetous acid, the fixable air always greatly exceeded the inflammable air in weight, as will be fhewn hereafter; and in all thefe cafes the quantity of fixable air was directly proportionate to the expenditure of pure air.

By thefe experiments I was thoroughly perfuaded that fome gravitating matter of pure air contributes to the formation of fixable air, and that every combuftible product of acetous acid, contains the acid principle of fixable air as well as phlogifton. As the phlogiftic products of acetous acid, when it is decompofed by fire, require no other matter but pure air in order to yield fixable air in confequence of their reciprocal decompofition, and this acid affords nothing but water and fixable air, exclufive of thefe

<div align="right">phlogiftic</div>

phlogiftic compounds, I could no longer doubt of the exiftence of the gravitating matter of pure air in acetous acid which yields fixable air; and the induction that acetous acid confifts of water, acid, air and phlogifton, feemed to me fully eftablifhed.

By the abftraction of fixable air, and con- fequently of the pure air of acetous acid, we deprive the remainder of this acid of every property that characterizes an acid, and by the due agency of air we reftore to a confiderable part of this fame remainder, the decided acid characters of fixable air. Therefore one of the principles of fixable air refides as well in our oil, tinder, coal or inflammable air, as in concentrated vinegar, although it fhews no property of an acid until it is combined with air.

Although the phenomena of combuftion were inexplicable, they furnifh no juft ar- gument in contradiction of thefe inferences concerning acetous compounds and air, fince by the experiments of the laft Section we find that nitrous acid acting on the oil of the

L   acetous

acetous and fupplying pure air, contributes
to the formation of fixable air, without the
aid of fire or the procefs of combuftion,
which has nothing peculiar to it except the
illumination; for fire is emitted wherever
fixable air is formed from the materials
above-mentioned, and is as manifeft in its
efcape from the mixtures which imprefs us
only with the fenfe of heat, and from which
it iffues flowly and progreffively, as in the
combuftion in which the fame matter, iffu-
ing more rapidly, and meeting no denfe
medium to alter or reftrain its motion be-
fore it is propagated to our vifual organs,
excites in us the fenfe of illumination. Thus
I endeavour to exprefs facts to which we
muft prefently have recourfe, without in-
volving them in any theoretic interpre-
tation.

This recent knowledge of acetous acid,
oily matter, fixable air, and denfe inflam-
mable air, opens to us a new profpect of
many interefting phenomena, which have
perplexed and mifled the moft ingenious
Experimenters. A concife and general ex-
planation

planation of thefe, according with our in-
terpretation of the phenomena already no-
ticed, will now I hope be acceptable to the
reader.

In diftillations of the acetous acid alone,
no change is produced in it, becaufe there
is nothing to facilitate an abftraction of its
water, or to detain any of its principles in
preference to the others, and becaufe the
volatility of this compound of water, acid
air, and phlogifton, limits the heat which
it fuftains in this procefs. But when the
fame acetous acid is detained by any body
which facilitates the abftraction of its water
which ferves as the intermedium of the
union of the other principles, and in confe-
quence of this detention is duly ignited, the
acid principle fo far as it meets air, forms
fixable air, but meeting phlogifton only,
forms with it an inflammable body, which
in the circumftances refpectively defcribed,
appears in the form of oil, tinder, artificial
fuel, or of denfe inflammable air.

In accounting for the production of fix-
able air, and of oil and inflammable air,

which

which in combuftion yield fixable air, from
the dephlegmated and ignited acetous acid,
we furnifh an eafy explanation of the phe-
nomena which occur in the diftillation and
combuftion of all the vegetable and other
fubftances which yield fixable air, oil, and
our inflammable air, in various proportions;
and we fhew at the fame time that however
they may vary in their other principles, and
confequently in their properties, they all
contain our vegetable acid principle affoci-
ated with phlogifton. The nature of the
coaly and charred refidue left in the diftil-
lation of vegetables and divers combuftible
mineral fubftances, is clearly fhewn by the
like refidues of acetous compounds; for fo
far as all thefe yield denfe inflammable air
by mere ignition, or fixable air in com-
buftion, the exiftence of our acid principle
in each of them is manifefted.

When we confider that in every dephleg-
mation of the acetous acid a great deal of
oil is formed, and that all oils in their com-
buftion fhew, by the quantity of fixable
air, that they confift chiefly of our acid
<div align="right">principle</div>

principle and phlogiston detained, in fome inftances, by a little earth or other fixed matter, and affociated, in others, with a little water ; and when we alfo obferve that waxy, refinous, bituminous, and divers other folid combuftible bodies may, by diftillation and the abftraction of earthy matter, be reduced to the ftate of oil ; we find fufficient reafon to conclude that the form and characters of oil are thofe which our acid principle and phlogifton, abftracted from other matter, are moft difpofed to af-fume ; and as no oil or ardent fpirit, or re-finous or camphorated or coaly fubftance, exifts without them, and nothing elfe is common to all the bodies that are com-buftible; I fhall for the future exprefs the compound of our acid principle and phlo-gifton by the term of oily or coaly matter, rather than introduce new terms.

As the moft dephlegmated acetous acid fuftains certain degrees of heat, and may be diftilled without decompofition, for the rea-fons above-mentioned, we readily conceive how ardent fpirits and the purer oily bodies

retain

retain their form and characters after the like treatment, and how camphorous bodies, flowers of Benzoin, and others, confisting chiefly of our oily or coaly matter, may be fublimed unaltered; and for the fame reafons that acetous acid duly heated, undergoes the changes already defcribed, ardent fpirits, oils, and all the volatile bodies which abound in our oily or coaly matter, are convertible, to the amount of this matter, into inflammable air, when they are detained by any body, or pufhed through red hot tubes, in order to undergo the neceffary ignition.

A curfory review of the particulars comprehended under thefe general obfervations, is fufficient to fhew how copioufly and extenfively our acid principle is diffufed through the animal and mineral as well as through the vegetable creation, how conftantly it attaches itfelf either to the gravitating matter of air, or to phlogifton, and why in all our attempts to expel it from fixed bodies, we find it compounded in the form of fixable air, inflammable air, or oil, which

which laſt bears the ſame relation to our acid principle that ſulphur has to that of vitriolic acid, or phoſphorus of Kunkel to that of the phoſphoric acid.

The fixable air, inflammable air and oil, procured in the diſtillation of wood, peat, bitumens and foſſile coal ; and the fixable air which is produced abundantly in the combuſtion of ſuch native ſubſtances, or of their oil or inflammable air, ſhew clearly that theſe fuels differ from each other only in the quality and quantity of earthy ſaline and other matter combined in them with the principles of our vegetable oil, which thus appears to be common to them all, and to conſtitute the greater part of them abſtracted from their water. Thoſe who wiſh to trace mineral fuel to a vegetable origin, will find the characteriſtic matter of it abounding in all organized bodies on earth, and even in their relicks after rotting, and may obſerve that black peat ſtrongly compreſſed, differs very little from mineral coal, either in the appearance, or analyſis, or products of combuſtion : and the circu-

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lation of the fame oily matter to vegetables
again, is exhibited in the practice of huf-
bandry. Virgin mould, however richly im-
pregnated with the matter of the vegetables
which have perifhed on it, is exhaufted by
the repeated removal of heavy crops, and
cannot by any culture or mixture be en-
riched again for vegetation, without re-
ceiving, in fome form, our oily matter,
which we thus trace into the crops, until
the exhaufted foil can bear no other than
ftunted vegetables fubfifting chiefly on the
nourifhment conveyed to them by the air or
rain.

The agency of water in vitriolic acid is
by all allowed to be the fame as we de-
fcribed it in regard to the acetous : hence
it happens that water impedes the action of
vitriolic acid on all bodies by which it can
be phlogifticated, and that vitriolic acid
and acetous acid, which however concen-
trated, contains a great quantity of water,
produced little or no effect on each other,
when they were mixed in equal quantities.
But when the proportion of water in the

<div align="right">mixture</div>

mixture was leſſened by adding only a little
of the acetous acid to a great quantity of
the moſt dephlegmated vitriolic acid ; and
when the acetous acid, detained in the vitri-
olic, diveſted of water, and conſiderably
heated at the ſame time, was deprived of
that part of it which iſſued in the form of
fixable air, the remainder then conſiſting
only of phlogiſton aſſociated with the vege-
table acid principle, was expoſed at once to
the action of fire and vitriolic acid, which,
as we ſhall preſently ſhew, contains pure
air, and always depoſites it in the act of
combining with phlogiſton, to form vola-
tile ſulphureous acid. Then whilſt the vi-
triolic acid became phlogiſticated, its air
acting as uſual on the hot oily matter, con-
tributed to the formation of fixable air.
But in proportion to the water which yet
remained to impede this decompoſition, a
part of the oleaginous matter eſcaped in the
form of ether or inflammable air, and a
portion of the vitriolic acid remained im-
perfectly phlogiſticated.

The action of vitriolic acid on ardent ſpi-
rits, oils, and all the bodies which contain

our oily matter, is of the fame kind : for weak fpirits are not fenfibly affected by this acid, and to produce the greateft alteration in both, we muft mix them in their moft dephlegmated ftate. Then the water, which is a conftituent part of alkohol, being detained by the vitriolic acid, and fome part of the acid principle of the alkohol being expended in the formation of fixable air which efcapes, fo much of the acid principle of the fpirit as can be faturated with its phlogifton to form an oily liquor, paffes off in diftillation, under the name of ether. This is followed by the water impregnated with fome concomitant ethereal and oily matter; and fo much of this laft as the vitriolic acid can detain, is afterwards expended in phlogifticating this acid by one of its principles to form volatile vitriolic acid, and contribute by its acid principle to produce the fixable air which accompanies the vitriolic acid air.

In the mean time a part of the oily matter thus heated, efcaping the action of the vitriolic, is expelled in the form of inflammable

mable air, to which this oily matter is al-
ways convertible by heat alone : and with
regard to the thick livid refiduary matter,
we need only obferve that it contains a con-
fiderable quantity of vitriolic acid unaltered,
and derives its fpiflitude and colour from
the falts of the vitriolic acid and the fac-
charine matter of the fpirit entangling a
portion of oil : but as the faccharine matter
itfelf confifts chiefly of the acid and phlo-
giftic and aerial principles of acetous acid,
the produce from this refidue by diftillation
to drynefs, is vitriolic acid, vitriolic air,
fixable air, and inflammable air in fmall
and variable quantity, for the reafons al-
ready mentioned.

In acetous acid and ardent fpirits the acid
principle predominates over the phlogiftic,
and is accompanied with fome air ; for
otherwife they could not yield fixable air,
as they do, in divers proceffes, without the
aid of pure air ; and fpirits could not render
falt of Tartar mild and cryftalizable, as they
ufually do in digeftion or diftillation. But
in oils, the acid principle appears to be fa-
turated

turated with phlogifton, and the quantity
of water which fuch a compound can re-
tain or unite with is, in all cafes, propor-
tionate to the quantity by which our acid
principle predominates in the oil; except
when fome other matter ferves like this as
the medium of union between the oil and
water.

This being the nature of oils, fo far as
we can briefly exprefs it in general terms,
we are next to confider the phenomena
which vitriolic acid and oily bodies have
been obferved to produce.

When diluted vitriolic acid is prefented
to an oil, they produce little or no effect
on each other, for the reafons above-men-
tioned : but when the dephlegmated acid is
ufed, its firft action is to abftract the water
and thicken and char the oil. The products
are afterwards fixable air, inflammable air,
vitriolic air, leaving a coaly refidue propor-
tionate to the heterogeneous falts in the acid
and the proper earthy or other fixed matter
of the refpective oils.

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To account for thefe products, we need
only make the obvious application of what
has been faid with regard to vitriolic acid
and acetous acid in diftillation.

In like manner, the production of fixable
and vitriolic air, and all that occurs when
we mix or diftil vitriolic acid with any ve-
getable or other fubftance abounding with
our acetous principle and phlogifton, are
eafily explicable, under due confideration of
the matter combined in thefe fubftances
refpectively with our oily matter, and of
the predominant acid, in fome inftances,
which with the concomitant air will afford
fixable air to which the aerial principle of
the vitriolic acid may not yet have contri-
buted.

As to the heat produced, on the mixture
of vitriolic acid with oily and other bodies
abounding with our acid and phlogiftic mat-
ter, it is manifeftly owing to the capacity of
the phlogiftic compound and of the vitriolic
acid feverally to retain more fire combined
in their fubftance, than can be afterwards
engaged

engaged as a component principle of the
fixable air, vitriolic air, or other product of
the procefs : and that the degree of heat
fhould be proportionate to the expenditure
of the air of the vitriolic acid in the form-
ation of fixable air, will not appear fingular;
when it is confidered that in the deflagra-
tion of our inflammable air with pure air,
fire is moft copioufly emitted, and nothing
remains but fixable air and water, except a
fmall and uncertain quantity of phlogifti-
cated air, as will more fully appear here-
after.

In comparing the inactivity of nitrous
and acetous acids on each other, with the
phenomena attending the mixtion of nitrous
acid with the oil of the acetous, we difcover
the agency of water in all fimilar mixtures :
for the acetous acid differs from this oil, in
nothing that affects the nitrous acid, except
water. The elective attractions of the phlo-
giftic and acid principles of the acetous acid,
and the aerial and acid principles of the
nitrous, the confequent decompofitions and
new products are therefore fufficiently exhi-
bited

bited in mixtures of this oil with nitrous acid, and serve to explain many phenomena which have occurred to Experimenters in their trials of nitrous acid with bodies containing the acid principle of acetous acid as well as phlogiston.

So far as the principles of our oil and nitrous acid were duly applied to each other, and unreſtrained by water, the phlogiſton of the former attached itſelf to the acid principle of the latter, and made nitrous air, whilſt the nitrous acid depoſited and transferred its air to be expended chiefly in the formation of fixable air : and as the new products could not retain all the fire originally combined in the oil and nitrous acid, a confiderable quantity of it neceſſarily eſcaping, acted in its proper character, heating and expanding the mixture and the contiguous bodies. But inaſmuch as the principles of the oil and acid were accompanied with water, and were reſtrained by it, or in imperfect mixture eluded each other, we had inflammable air or oily vapour in conſequence of the heat, and nitrous vapour or acid partially phlogiſticated.

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In this manner and even in thefe terms we can eafily account for the products and phenomena of nitrous acid with divers vegetable and animal fubftances, which contain our acid principle and phlogifton, viz. the heat, the intumefcence, the nitrous and fixable air, the efcape of inflammable air and oily vapour, and the femi - phlogifticated ftate of fome part of the nitrous acid.

Many experiments admitting or requiring this explanation, may be met in the works of the lateft writers on chemical fubjects, and particularly in Dr. Prieftley's fecond volume of Experiments and Obfervations on Airs : but in every expofition of this kind, due care fhould be taken that the fixable air which the phlogiftic body alone may yield, be not confounded with that to which the air of the nitrous acid contributes.

In explaining the phenomena attending the mixture of nitrous acid with bodies confifting chiefly of our oily matter and water, the agency of this laft is efpecially to be confidered. The firft effect of the nitrous acid

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in thefe cafes is, like that of the vitriolic, to
abftract the water, and then act like diluted
nitrous acid on the other matter of thefe
bodies : fo nitrous ether is made from fpi-
rit of wine and this acid, of which fome
part remains in the water abftracted from
the ethereal or oily matter, another part
blends with the ether, when heat is avoid-
ed, whilft a portion of the pure or empy-
real air is expended in the generation of
fixable air; and proportionate to this ex-
penditure we find nitrous and phlogiftic air,
the quantities of which are greateft when, by
extraordinary dephlegmation of the acid and
fpirit, or by the heat of hafty mixture, or
the want of due compreffion, the action of
thefe laft on each other is rather promoted
than moderated.

Subftances which confift almoft entirely
of our oily matter, and afford little or no
water to dilute the nitrous acid and mode-
rate its action, produce the greateft quanti-
ty of fixable and nitrous air; which are ex-
pelled with fuch impetuofity as to blow a
great part of the ingredients away, before

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they can be blended sufficiently for their mutual decompofition. This happens in mixtures of nitrous acid and effential oils, which always emit a great quantity of fire, generally burft forth into flame, and burn with great rapidity. When the decompofition is partial or incomplete, the fire emited is partly wafted away with the elaftic fluids newly compofed, and partly expended in vaporizing the undecompofed parts of the ingredients ; but when neither water nor any other matter gives any confiderable impediment, and the circumftances favour the action of fuch bodies on each other, they are almoft wholly expended in forming the new compounds of firable air, nitrous air, phlogiftic air, and water ; and the vivid flame and intenfe heat fhew that the fire which was lodged in the oily matter, and in the air of the nitrous acid, is for the greater part liberated to act in its proper character on the neighbouring bodies.

All the phenomena that accompany the action of nitrous acid on other bodies, which like thefe contribute to the formation of

fix-

fixable air, are fimilar to, and intermediate between thofe of folutions, of the proceffes for ether, and of the inflammation of oils, and differ from them in nothing that can embarrafs an experienced chemift.

Notwithftanding the attractive power with which nitrous acid is combined in alkalies earths and metals, the force where-with its empyreal air is drawn to the prin-ciples of our coaly matter, is always fufficient under due ignition, to produce the effects lately defcribed, and particularly the for-mation of fixable air and nitrous air, which is often accompanied with a confiderable quantity of phlogiftic air. This laft indeed varies greatly, as the circumftances of the procefs and the fubjects of it are varied ; but does not require immediate attention.

The rapid combuftion and explofive pow-er of compounds, confifting of nitrous falt, well mixed in due proportion with charcoal or any other fubftance confifting chiefly of our acid principle, combined with phlo-gifton, are neceffary confequences of thofe

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attractive forces which tend to the forma-
tion of fixable air, nitrous and phlogiftic
air and water, and to the liberation of the
matter of fire. Our recent knowledge of
thefe fubjects is chiefly derived from that
important difcovery of Mr. Cavendifh, of
the emiffion of fire and formation of water,
from the gravitating matter of empyreal
and light inflammable air ; and any perfon
who may hereafter compofe a theory of
combuftion and detonation, will find the
chief difficulty to confift in the attempt
to fhew why a combuftable mixture, whe-
ther elaftic, fluid, or folid, requiers ignition
in fome part before the intended decompo-
fition can take place. My conjectures on
this fubject will appear in a fubfequent
fection.

A great many different pyrophori are made
by mixing earthy, metallic, or alkaline bo-
dies, with vegetable or animal fubftances
confifting chiefly of our oily matter, and
then expelling their moifture and fuper-
fluous oily or acidulous matter, by ignition
in clofe veffels. Nothing but this oily or

coa-

coaly matter is common to all the pyrophori, which by mere expofure to pure air, imbibe it fuddenly, enter into combuftion, and yield fixable air ; which, if it be not copioufly emitted during the combuftion, is found to be detained in the earth or alkali of the pyrophorus, from which, previous to the admiffion of air, little or no fixable air could be obtained. The fixable air formed in all inftances of this kind, is manifeftly the product of the oily or coaly matter, and pure or empyreal air ; and the fire liberated and fpontaneous accenfion, fhew clearly that one or both of thefe contained a much greater quantity of fire, than the new products, confifting of fixable air water and refiduary grofs matter, can retain.

After this manner, we may eafily explain the phenomena of fixable air and heat wherever they are produced, during the action of empyreal air, (or atmofpheric air which contains it) on fubftances containing our oily or coaly matter ; and the fame interpretation is applicable, wherever we fee fixable air formed, and fire extricated

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during the action of nitrous falts, black
wad, or of other bodies containing empy-
real air, on combuftible bodies holding our
oily or coaly matter. But fince mixtures
of folid bodies containing empyreal air in-
timately combined in them, with other
folid bodies containing our oily matter,
emit fire abundantly, and burn moft ve-
hemently, fo foon as the action of the aerial
matter of one, on the oily matter of the
other, commences, whether fpontaneoufly,
or by the excitation of a flint fpark ; we
cannot doubt that the empyreal air, or
oily matter, or both, retain a vaft quan-
tity of fire fixed in the folid fubftance and
as much neutralized as acid is in a neutral
falt : and in comparing the action of the
elaftic fluid called empyreal air, in the
combuftion of phlogiftic bodies, with the
like effect of nitrous and other folid bodies,
which act in combuftions by virtue of
their pure air, we find no ground for fup-
pofing that much more of the matter of
fire is neceffary to the elaftic condition of
pure air, than can be retained by it in the
clofer approximation of its parts, in bodies

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to whofe mafs and weight it greatly con-
tributes ; unlefs we admit, that fire is com-
bined in much greater quantities in phlo-
giftic bodies than in any other ; in direct
contradiction to the opinion of the ingeni-
ous Dr. Crawford, who very juftly confi-
dered the empyreal air as the vehicle of
fixed fire ; but will now, on a review of
the fubject, if I miftake not, admit, that
phlogiftic bodies alfo contain fire, and emit
it in combuftion. But the vivid com-
buftions of *light inflamable* air, fulphur,
zinc, and other bodies, with pure air, in
which little or no fixable air is formed,
as that excellent philofopher Mr. Caven-
difh has fhewn ; teach us that fixable air
is not a neceffary product of combuftion,
nor of the union of air with phlogifton :
And now we fee, that it cannot be produ-
ced by the union of air with any known
matter, except the acid principle mani-
feftly contained and difguifed by phlogif-
ton, in the bodies comprehended under
the general heads already fpecified, and con-
fequently in fubftances whofe varieties,

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dif-

diftinguifhed only by the names, would fill a volume.

The proceffes of fermentation, putre-faction and refpiration, which laft, as Dr. Crawford very fagacioufly obferves, gene-rates animal heat, are all productive of fix-able air, of which, a great part is actually formed from principles which before were otherwife engaged and compounded in the refpective inftruments of thefe operations; and thefe proceffes are all attended, like thofe above defcribed, with the emiffion of fire, But as I intend to fpeak of thefe fubjects elfewhere, I fhall not infift on them here for the mere purpofe of fhew-ing, what the reader anticipates, their con-formity with the notions fo often tried in the interpretation of the phenomena which accompany the formation of fixable air in various proceffes.

The appearance of fmall quantities of fixable air, in proceffes which do not rank under any of the forgoing heads, is gene-rally

rally owing to the following circumstan-
ces: The common nitrous acid of the
shops is distilled from rough nitre, and ex-
clusive of water, carries with it some of
the vegetable oily matter, which colours
it, and in every circumstance of deplog-
mation and ignition, yields fixable air.
In the refining of nitre, we approximate
the intended purity, but never attain it
perfectly; and therefore find some fixable
air mixed with the first product of nitre
distilled even in glass vessels. The moats
also, or dust and fibres, whether animal
or vegetable, that are wafted every where
in the air, and adhere to our vessels and
instruments, never fail to impregnate the
subjects of our experiments, and to yield
fixable air, when exposed to heat and the
action of air or of bodies containing this
matter. Coarse earthen vessels generally re-
tain in their substance some of our oily or
coaly matter; the imperfect metals are
seldom free from it; and a grain is suffi-
cient in the recited circumstances, to pro-
duce some cubic inches of fixable air, as
will be shewn hereafter. It is not, there-

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fore a matter of furprife, that in the in-
confiderate ufe of impure materials, earthen
veffels, dirty gun barrels, and by expofure
to the common air, many fubftances fhould
have appeared to yield variable quantities
of fixable air, which in the contrary cir-
cumftances could have afforded nothing of
this kind.

We cannot yet fpeak with certainty of
the character of the mere acid matter of
each of the chemical acids, abftracted from
phlogifton and every other kind of gravi-
tating matter. In each of the fubftances,
which we confider as a certain acid fatu-
rated with phlogifton, the acid matter is
as much difguifed as it can be in a neutral
falt : This appears in the comparifon of
fulphur with vitriolated tartar, of phofpho-
rus with microfmic falt, of regulus arfenic,
with neutral arfenical falt, &c. all which
differ very much from their refpective acids.
But as empyreal air is adminiftred in every
procefs in which we are fuppofed to de-
phlogifticate the mere acid matter, and
this laft is not known to us in the ftate
in-

intermediate between that of its combination with phlogifton and this laft in which it is certainly combined with gravitating matter of empyreal air, we cannot pretend to defcribe any mere acid matter in its uncombined ftate; nor is it yet demonftrated, that the empyreal air, which is a conftituent part of each of the acids of the chemifts, expells or extricates in every inftance, all the phlogiftic matter which was formerly combined in the fubject from which the acid is prepared. There is, however, in the preparation of every acid, fufficient evidence either of the expulfion of fome phlogiftic matter, or of its union with the pure acid matter being diffolved in confequence of its being expended in the formation of water, of which a part, or the whole in moft inftances, is retained in the body which we are faid to dephlogifticate.

Whenever vitriolic acid is employed in the formation of fulphur, its empyreal air is expended in forming fixable air or water; the acid character of the refidue is loft in

the

the union with phlogifton, and cannot be
reftored until empyreal air is adminiftred
in fome fhape to combine with the mere
acid matter and with a part if not the
whole of the phlogifton, which with a pro-
tion of the empyreal air forms water.

This agency of empyreal air appears in
every procefs for making vitriolic acid from
fulphur and nitrous acid or nitrous falt, or
fulphur and empyreal air, whether admi-
niftered pure, or blended with phlogiftic air,
as it is in atmofpheric air; and the extri-
cation of the empyreal air from the other
matter of vitriolic acid, whilft it is em-
ployed in the formation of fulphur, is equal-
ly apparent in every experiment in which
artificial fulphur is formed in confiderable
quantities, as in making liver of fulphur
with charcoal and vitriolated tartar or glau-
bers falt, or in making pyrophorus with
alum and flower or fugar; for in thefe in-
ftances, and in every diftillation of vitrio-
lic acid or vitriolic falt with charcoal, coak,
bitumens, oils, refins, and divers fubftances
which feverally yield little or no fixable
air

air or water until empyreal air acts on them
during ignition, the quantity of fixable air
and water produced during the intended
formation of fulphur, shews that the pro-
per air of the vitriolic acid, is excluded
from the fulphureous compound.

Although vitriolic acid be divefted of
water in the long continued fusion of glau-
bers falt, it obftinately retains the greater
part of its empyreal air; and until this is
engaged and expended in the formation of
fixable air and water, the vitriolic falt can-
not make liver of fulphur with charcoal or
the other fubftances that abound with our
coaly matter. The agency of this laft in
the extrication of the empyreal air of glau-
bers falt, is the fame as in metallic reduc-
tion; and the liver of fulphur thus made
by fusion, shews how much the acid cha-
racter of vitriolic acid depends on its em-
pyreal air: For the faline mafs now con-
taining almoft all the mere acid matter
which belonged to the Glaubers falt, but
deprived of the air, is no longer neutral and
mild, but taftes ftrongly alkaline and cauf-
tic,

tic, and is deliquefcent. Expofed to em-
pyreal air it imbibes it greedily, and with-
out meeting any other matter, refumes the
characters of Glaubers falts. Vitriolated
tartar treated in the fame way, affords the
fame phenomena and inferences.

The nitrous acid, in like manner, lofes its
acid characters, and acquires thofe of nitrous
air, when it is deprived of the empyreal
air, and is fuppofed to receive phlogifton,
in metallic folutions, or in combuftions
and detonations. When the quantity of
nitrous air is confiderable, the empyreal air
which had been detached from it in fuch
proceffes, is eafily traced in the bodies which
effected the feparation, as in the nitrated
calces, or in the water formed, or in the
fixable air ; and the nitrous air never re-
fumes the true characters of nitrous acid,
until it meets empyreal air, with which
it recompofes nitrous acid and its water.

It is not to be denied that in proceffes
of this kind, as well as in the expulfion of
empyreal air from nitre, a confiderable
quan-

quantity of phlogiftic air appears, of which
I cannot yet fpeak with precifion, although
I am certain there is nothing in it repugnant
to thefe notions of acids.

Phofphorus of Kunkel, as the celebrated
Scheele and Lavoifier have fhewn, imbibes
empyreal air in great quantity. During its
faturation with the air, nothing but fire is
perceptibly emitted, and this which has
been called dephlogiftication, is really ef-
fected without any emiffion of the phlogiftic
matter, becaufe there is no lofs of weight,
and water is manifeftly formed.

In the phofphorus, the acid matter is
totally difguifed by the combination with
phlogifton ; in the tranfition to phofphoric
acid it may be equally difguifed, becaufe it
combines with the gravitating matter of
empyreal air ; but it is only in this com-
bination with air that it forms a fubftance
poffeffing the common chemical characters
of an acid.

How the mere acid principle of phofpho-
rus would act, if it were perfectly freed from
phlogifton and empyreal air, I know not ;
but I am affured that the empyreal air is
not all expended in forming water with
the phlogifton of the phofphorus, and that
it does not act merely by diffolving the
union between the phlogifton and acid
principle, which in the latitude of fpeech
may ftill be called dephlogiftication ; for
the aftonifhing quantity of empyreal air
which phofphorus imbibes in combuftion,
to the amount of about twice its own
weight, is not all emitted in the form of
water, but ferves as well as difengaded
empyreal air, for the greater part, to com-
pofe fixable air, when the phofphoric acid
is formed into phofphorus again, by diftil-
ling it with charcoal or other fubftances
containing the acid principle of fixable air.

Arfenical matter combined with phlo-
gifton to form Regulus of arfenic, has more
of the character of a combuftable metallic
fubftance than of an acid ; and it is only
by

by abforbing empyreal air in due quantity, that it acquires the general properties of a chemical acid. That this empyreal air is not wholly expended in abftracting the phlogifton, but that it actually contributes to the formation of the acid, may eafily be fhewn, 1ft, by the fixable air which is produced in great quantity during the reduction to the reguline ftate by fuch phlogiftic fub-ftances as contain our oily or coaly matter ; 2dly, by the empyreal air which this acid emits when it is ftrongly ignited and fub-limed into the form of white arfenic ; and 3dly, by the rapid combuftion of zinc fufed in this acid, as Mr. Scheele has obferved.

In the preparation of the acid of fugar and of other factitious vegetable acids, all the phenomena correfpond with thefe no-tions of the acids in general, and with no others. The nitrous acid employed in fuch proceffes is wholly expended thus : its empyreal air in forming water and the vegetable acid, whilft the remainder of it efcapes in the form of nitrous air, if not of

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phlogiftic air : The empyreal air thus de-
pofited in the faccharine or other vegetable
acid, is demonftrable, in the greater quan-
tity of fixable air that may be expelled by
mere ignition from fuch an acid, than from
an equal weight of the fugar or other fub-
ftance which was formerly fuppofed to con-
tain fuch acid difguifed onlyby phlogifton.

We are indebted to the ingenious Mr.
Scheele and Mr. Lavoifier for many excel-
lent experiments and obfervations, which
illuftrate all that is here advanced concern-
ing the matter of acids and pure air, al-
though their conclufions concerning phlo-
gifton and fixable air are exceptionable, as
is the ufe of the term oxygenous principle ;
for as empyreal air is common to many other
bodies as well as to the chemical acids, and
contributes to the formation of acid, only
when it combines with and dephlogifticates
fome particular kind of matter, the term
oxygenous principle is applicable rather to
this laft than to the empyreal air, and it is
only in this latter fenfe that we want it.

The

The marine acid eludes this analogy in no other particular than the ftronger ad-hefion of the empyreal air, which we cannot feparate totally from the acid matter by any art yet difcovered.

When dephlogifticated marine acid is prepared, by mixing the nitrous with the common marine acid, the change produced in this laft, is proportionate to the quantity of nitrous air which is always produced and emitted from the mixture, and confe-quently to the quantity of pure air which is drawn by the marine acid from the ni-trous': thus, dephlogifticated marine acid made in this way, appears to confift of ma-rine acid faturated with empyreal air : and as the menftrual power of every acid is abated by phlogifton, and encreafed by the acceffion of empyreal air; fo the fully aera-ted marine acid becomes a folvent of bodies which refift the ordinary marine acid.

But independent of the intenfity which an acid folvent acquires by the acceffion of air, the nature of metallic falts and calces,

re-

requires that the folvent fhould fupply pure air abundantly; for, as this air is a neceffary conftituent principle of fuch bodies, the tranfition from metal to falt or calx, can take place only as the menftruum fupplies air. Hence the efficacy of nitrous acid in calcining metals, and of the dephlogifticated marine acid in diffolving thofe which refift the common fpirit of falt.

On thefe confiderations, the marine acid does not yet appear as an exception to thefe notions of the agency of empyreal air in acids; nor will it afford any ftronger objection to them, after the relation of the following phenomenon, which has not, to my knowledge, been noticed by any chemift.

The acid elaftic fluid which iffues when two pounds of manganefe are mixed and diftilled with two or three of ordinary fpirit of fea falt, may all, except a fmall portion of phlogiftic air, be condenfed in a folution of fixed vegetable alkali; and the

folution

folution thus impregnated, yields a con-
fiderable quantity of nitre, which cryfta-
lizes in the ordinary form, and detonates
on red hot coals. The folution at the
fame time yields regenerated fea falt.

It is to be obferved, that manganefe, by
mere ignition, yields a great quantity of
empyreal air with phlogiftic air, as nitre
does; and from thefe facts I conclude,
that manganefe contains nitrous acid or
the principles of it in great quantity.

But red lead, and the calcis which ferve
to dephlogifticate the marine acid, or to
produce the change in it that is expreffed
by that word, alfo yield empyreal and
phlogiftic air by ignition ; and I venture
to prognofticate, that nitrous acid will
alfo be found in thefe cafes to make aqua
regia with marine acid, exclufive of any
change producible in the marine acid, by
its union with empyreal air fupplied from
the calx.

Since

Since air then is a conftituent principle of all thefe, and neceffary towards their acid character, and fince the marine acid affords no contradictory inftance, it is perfectly conformable tot he tenour of nature, that acetous aced fhould contain air and poffefs the acid character, as much by virtue of this air as of any other matter of it; and as the union of a fpecific matter with phlogifton, makes fulphur, but with air, vitriolic acid; or as the union of a certain kind of matter with phlogifton, makes phofphorus, but with air, phofphoric acid; it is perfectly conformable to the known nature of acids, that the peculiar matter which diftinguifhes the acetous from other acids, fhould attract phlogifton, and in this union exhibit none of the acid characters, but appear as an oily or camphorous or refinous fubftance, bearing ftrong refemblance, in divers properties, to fulphur or phofphorus, and a weaker fimilitude only when it is overwhelmed with other matter, as it is in fpirits, fugar, gums, vegetables, foffile coal, &c.; and finally that by receiving

empyreal

empyreal air, and depofiting a part of its phlogiftion, it fhould affume the acid cha-racters that appear in acetous and other ve-getable acids and in fixable air.

In fpeaking of fulphur, the fubjects which claimed my chief attention, did not require that I fhould deviate from the common notion of its being compofed of mere acid matter and phlogifton; but it is now expedient. to declare that in a great number of experiments it appears to me that fulphur contains a fmall portion of our oily matter; and it is owing to the prevalence of the vitriolic acid, that the fmall quantity of fixable air, which is formed during the combuftion of fulphur, does not fhew itfelf by the teft of lime water prefented to the acid vapour.

Inductive reafoning is ever liable to error, but approaches the nearer to be con-clufive, as the induction is more general, free from experimental exception, and ap-plicable in the folution of phenomena, which do not appear to be explicable

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upon

upon any other general ground. The matter of this section then is to be considered rather as a test and probation of my notions concerning acetous acid, fixable air, oil, and dense inflammable air, than as an attempt towards explaining, in so small a compass, all the phenomena that have been noticed on this occasion.

The terms which have been hitherto used by chemical writers, are in many instances utterly unfit for these discussions, and render them as embarrassing to the writer, as they may be obscure to an inattentive or captious reader. The most correct of our writers have felt this inconvenience; and until the new notions are adopted by general consent, philosophers will rather continue to read with candour and indulgence, than encourage the premature introduction of new terms.

SECTION XI.

Experiments and Obfervations on Acetous Compounds Containing Volatile Alkali; and Reflections on the Varieties Analyfis and Products of divers Subftances.

THE new and unexpected appearances which occurred to me in my firft experiments on acetated volatile alkali, prompted me to repeat them often on a very large fcale, and to vary them fo much, that a full detail of all that relates to them cannot be introduced in this effay. I fhall however give a fummary view of the particulars which feem to be remarkable, either for their novelty or their aptitude to our purpofe of tracing the principles and properties of acetous acid.

The water inherent in the concentrated acetous acid and in the rectified volatile alkaline falt of fal ammoniac, is fufficient to keep the neutral falt which they form, in perfect folution. But the neutral li-

quor

quor fhews a confiderable degree of tena-
city or fpiffitude, although it be colourlefs
and tranfparent.

In neutralizing the acid with a cauftic
volatile alkaline liquor, confifting of fix
parts of water and one of mere alkali, the heat
excited amounts to 150°; and as the alkali
ufed is ftronger the heat is greater. The
denfe white fume which clouds the vef-
fels in which this mixture is made, con-
fifts chiefly of neutral falt formed by the
union of the acid vapour with the alkaline
air which continually iffues from the al-
kaline liquor when it is preffed by the at-
mofphere only, without any intermediate
impervious body.

The uncommon duration of this denfe
white vapour, or the flow condenfation of
it into a neutral falt, implies a flow extri-
cation of the proper fixed fire of the acid
vapour and alkaline air in confequence of
the counteraction of contrary powers.
For the parts of the acid and alkali tend
to retain their refpective portions of fire,
                                    though

though not fo ftrongly, as the attraction which draws them into contact, tends to exclude the greater part of it, as it happens in the formation of the neutral falt.

When the acid is neutralized by concrete mild volatile alkaline falt, of which it requires about an equal weight, the mixture is rather cooled than heated in temperate weather; fhewing that the fixable air expelled from the alkali, engages and carries off with it, in a ftate of combination, all the fire which otherwife would fhew itfelf under its proper characters.

In diftilling the neutral liquor, the firft effect of the heat is to expel a confiderable part of the alkali in the cauftic and aerial ftate, and the emiffion of alkaline air continues until the liquor condenfed in the recipient, amounts to one fourth of the bulk of the charge.

This being drawn off and examined is found to confift of water faturated with cauftic volatile alkali, and impregnated

with.

with a part of the neutral falt which pasfes over along with the watery vapour, and of which the quantity is greateft in quick diftillation, but rarely exceeds one eighth of the neutral falt employed.

What follows, is for a moment neutral, but after a few drops, iffues ftrongly acid to the tafte, and confifts of water, acetous acid and neutral falt, a part of which cryftalizes in the acid liquor, in cooling; and the product is of this kind, until the original charge is reduced to about half its bulk.

After this, the matter in the retort becomes neutral, and then concrete and cryftaline by cooling: But by flow fublimation it forms long flender flatted cryftals terminating in fharp points, fhooting from the fides of the veffels in divers directions, irregularly piled on each other, but leaving large interftices, and having no predominance of acid or alkali, to the tafte: Their hue is pearly white, and their length feldom

dom exceeds an inch and eight tenths, but is much lefs in hafty fublimation.

The cryftals which form towards the con-clufion of the procefs are not fo white as the former, and the laft of all are yellow, as if ftained with oil. A very thin cruft of fixed black matter always remains at the bottom of the retort, adhering firmly to it, and too fmall in quantity to admit of ftrict examination.

The white cryftals have a peculiar fmell, which differs confiderably from that of the yellow, which is a little offenfive, and not unlike that of the fmoak that iffues during the combuftion of fucculent vegetables for potafh. Thus the neutral liquor af-fords firft the volatile alkaline odour, then the acid varioufly modified, then divers gradations in the fmell of the neutral fub-limate, until it becomes empyreumatic.

When a weak folution of acetated vola-tile alkali in water, fuch as may be made with acetous acid and the cauftic volatile
<div align="right">fpirit</div>

spirit of fal ammoniac, is flowly diftilled, the volatile alkari arifes in greater quantity, in the beginning of the diftillation, and requires fome water to be prefented in the receivers, in order to condenfe it, until a fufficient quantity of watery vapour iffues along with it from the charge. This alkalized water ferves to neutralize the acid liquor which follows it, until the matter remaining in the retort becomes neutral. Although the greater part of the acetated volatile alkaline falt is thus decompofed in diftillation with water, yet a confiderable fhare of it may, in this procefs, be dephlegmated, becaufe it is lefs volatile than water. But for this purpofe the diftillation muft be very flow; otherwife the difference in volatility is not fufficient to to prevent the falt from paffing over along with the water.

The whiteft cryftals, heated again in clofe veffels, melt and fublime into white cryftals like the former, until the charge is reduced to about $\frac{1}{5}$ or lefs; then the fublimate fhews a yellowifh tint, which

encreafes

encreafes to the end, and a black ftain is left on the bottom of the retort, but nothing elfe that merits any confideration in regard to the quantity of the charge.

The yellow cryftals fublimed again, afford a white fublimate at firft; but towards the middle of the procefs the cryftals laft formed incline to yellownefs, which encreafes gradually in every fucceffive crop. The bottom of the retort fhews a ftain or film which blackens it, but not any quantity of fixed refidue that the tendereft balance could fhew in weighing the whole charge.

About this period of the procefs, the air in the veffels becomes impregnated with fixable air mixed with a fmall quantity of inflamable air, the caufe of which will be confidered hereafter.

The fame phenomena occur in the fifth, fixth and feventh fublimation of thefe cryftals, by a very gentle and fteady heat.

The

The quantity of alkali predominating in the firſt product by diſtillation from the acetated volatile alkaline liquor, is greater as the diſtillation is more ſlowly conducted. In this caſe, that part alſo which diſtills with exceſs of acid is greater, and becomes ſtrong even to cauſticity about the time when the neutral dephlegmated reſidue is fit to concrete by cooling : and the portion of neutral ſalt, which riſes along with the alkaline and acid liquors, is, in this circumſtance, ſmaller than it ever is found in quick diſtillations.

Acetated volatile alkali, in its dry cryſtaline form, and perfectly purified by five ſublimations, melts at the temperature of 170, and ſublimes at 250 or thereabouts. It is combuſtible, very deliqueſcent, and impreſſes the tongue firſt with a ſenſe of coldneſs and then of ſweetneſs, which is ſoon followed by the kind of taſte that may be given by a mixture of nitre and ſugar, in which the ſweet is not to predominate over the mawkiſh taſte of nitre.

The laſt ſallow cryſtals obtained in the ſublimation of large quantities of acetated volatile alkali, have a taſte not unlike that of ſugar made brown and empyreumatic by fuſion, are odorous in their drieſt and coldeſt ſtate, and ſmell like the yeaſt of fermenting melaſſes.

As the neutral cryſtals of acetated volatile alkali may be heated and ſublimed repeatedly without loſing the alkali, and the ſolution of the ſame ſalt undergoes a partial decompoſition in diſtillation, the firſt product being alkaline, the ſecond acid, and the dephlegmated remainder neutral; water appears to be the chief agent in this decompoſition, and to have conſiderable effect in weakening the union of the acid and alkali.

This acetated volatile alkaline ſalt copiouſly precipitates nitrous ſolution of ſilver, by virtue of compound affinities, and a conſiderable predominance of acetous acid will not prevent this effect. This fact demands

conſiderable

confiderable attention, in the ordinary ufe of the folution of filver, to detect marine and vitriolic impregnations.

The falt compofed of acetous acid and volatile alkali, can not be decompofed by lime as it is reprefented in Bergman's Tables.

A fmall portion of lime combines with the falt, and expels a little of that part of its volatile alkali which is fo weakly retained in the acetous falt, that it iffues, as we have obferved, even before the water, in the diftillation of folutions of this falt.

Every ounce of the neutral falt combines with a penny-weight of the lime, and the liquor holding a falt of three chemical principles, viz. acetous acid, volatile alkali, and lime, may be evaporated to the confiftence of olive oil, without depofiting any lime or lofing any of the faline ingredients. The tafte of the neutral falt is totally altered by this affociation with lime; and the lime may be recovered by precipitation

precipitation with fixed alkali, and will then form felinite with vitriolic acid; fo that it undergoes no alteration.

Magnefia operates in a fimilar manner, with the acetated volatile alkali; and when the falt of three principles, whether holding lime or magnefia, is gradually heated in clofe veffels, the chief part of the acetated volatile alkali fublimes, white at firft and afterwards coloured; but that part which is detained in the earthy matter until it fuftains a greater heat, is partially at firft, and towards the end totally decompofed, when the heat is increafed. The volatile alkali mixes with the oily and watery product, which is fimilar to that of acetous acid in other experiments; and the quantity of fixable and inflammable air, is proportionate to that of the acid detained, until it fuftains that heat which alone is in all cafes fufficient for the converfion of acetous acid to water, oil, fixable and inflammable air.

In

In this treatment of acetated volatile al-
kali, the fmell and tafte are incredibly va-
ried, with every change of proportion and of
the degree of heat which the principles of it
undergo.

The refiduary lime or magnefia in fuch
diftillations, has all the appearances and
properties of the like refidues from ace-
tous calcareous falt or acetated magnefia.

The facility with which volatile alkali
efcapes, in a very weak heat, from acetous
acid, when their union is weakened by
water, implies that the like decompofition
may more eafily be effected when the acid
is held by matter which attracts it more
forcibly than water, and the alkali meets
fixable air or other matter, fo that the extri-
cation of the acid from the alkali may be
effected by compound affinities : and on
this ground we may account for the pro-
duct of volatile alkali in the diftillation of
muftard, opium, tobacco, and of divers
other vegetable fubftances, whofe decoc-
tions and infufions are neutral, and which
certainly

certainly contain all the principles of ace-
tous acid, becaufe they yield fixable air,
inflammable air, and oil in diftillation.

The fame properties of acetated volatile
alkali, and its extreme volatility in diftilla-
tion coction or fublimation, affifts us in
explaining the changes which, to the fur-
prize of the ableft chemifts, are produced
by the coction or diftillation of divers ve-
getables, particularly thofe arranged in the
Materia Medica under the head of Anti-
fcorbutics, and lead us to a true analyfis
which fhall exhibit the quantity of this
volatile falt or of its principles, as well as
that of the earthy watery and fixed faline
matter already difcovered in vegetable
bodies. We fee that the purer oily mat-
ter of vegetables, confifting of phlogifton
and the acid principle of acetous acid, and
which fpontaneoufly exhales and diffufes
itfelf in air, maintains a great part of its
volatility and odoriferous quality even in
conjunction with volatile alkali ; and no-
thing but experiment is wanting to fhew
volatile alkali, or other matter, acting a

fimilar

fimilar part in the compofition of the oily
fublimates refembling camphor, or ben-
zoin flowers, and in the more faline fubli-
mates from vegetable fubftances, all of
which abound with our oily matter.

The appetence of fire which we con-
ftantly experience in fixable air, and the
confequent facility with which it is ex-
pelled from bodies by fire; the like ap-
petence of the phlogiftic and acid matter
of acetous acid, and the incapacity of even
fixed alkalies to retain them under the im-
preffion of fire; the efcape of acetous acid
during the coction of the folution of
acetated vegetable alkali; and in a word
the recited properties of acetated volatile
alkali, point out to us the laws of attrac-
tion, or ultimate reafon in natural philofo-
phy, by which we are to account for the
alkaline, acid, neutral, aerial, and fixed
products, fo diffimilar in property and
quantity, which the very fame fubftan-
ces have been found to yield in coction,
fermentation, putrefaction, diftillation *per-
fe*, and in other proceffes.

The

The singular relation of acetous acid to volatile alkali, lime, and magnesian earth, whereby three or more of these may be held in the same salt, is to be considered only as one of many instances of the capacity of this acid to form saline bodies uncommonly compounded, inseparable by the usual arts of crystalifation, and partially or totally convertible by heat. This is to be enumerated amongst the causes which produce that wonderful variety in substances, every one of which abounds with the principles of acetous acid; and it is also to be ranked amongst the impediments to a compleat analysis of vegetable bodies.

But although volatile alkali, induces the varieties and appearances lately mentioned in acetous compounds, it is to be observed, that it is not more effectual than water in impeding the conversion of the acetous acid by fire; for so much of the acetated volatile alkali, as is duly igitned in any procefs, undergoes the same decomposition that happens to other acetous compounds; and nothing has yet been discovered that

can

can prevent this converſion of the acetous acid by fire.

There is no difficulty, therefore, in accounting for the ſtain left on the retort in ſubliming acetated volatile alkali ; for the moats and duſt which it muſt neceſſarily catch from the air, in charging, or from the retort, however clean it may appear, added to the matter abraded from the glaſs during the operation, and aided by the attraction of the veſſel to the ſalt, are ſufficient to detain a ſmall quantity of the acetous compound, until it acquires the heat in which every fixed matter becomes ſtained with the reſiduary oily matter of ignited acetous acid. This notion of the phenomenon is ſupported by the appearance of fixable air mixed with a little inflammable air, at this period of the proceſs.

The varieties of ſmell and taſte which an acetous ſalt exhibits in conſequence of variations in the proportions of its principles, ſerve to ſhew, that in the analyſis of vegetable and other bodies which differ greatly

in fmell, tafte, and appearance, we are not to
expect as great a difference in the kinds
of matter of which they are compofed,
but are more likely to find in thoufands
of them, little or nothing more than
a certain earth, and alkali, and phlogi-
fton with one or both of the gravitating
principles of fixable air. This expref-
fion to preclude the confideration of the
matter of fire, may be conveniently ufed,
until we find by direct experiment that
this matter gravitates.

S E C-

SECTION XII.

Preparatory Experiments on red Lead, Lith-
rage and Lead, and Eſtimate of the matter
imbibed or expelled in calcination and re-
duĉtion.

WITH a view to the following experi-
ments with calces of lead and acetous
acid, I made very accurate aſſays of lith-
rage and red lead, the particulars of
which I omit, as it will be ſufficient for my
preſent purpoſe to ſtate the following
facts.

The ordinary red lead of our manufacto-
ries, muſt be ſlowly dried in a heat not ex-
ceeding 150 degrees, before the weight
can be aſcertained with accuracy. After
this the quantity of water that can be ob-
tained from it in a greater heat is very in-
conſiderable, even when the heat is ſuffici-
ent to expel ſome of the fixable, phlogiſtic,
andempyreal air of this calx. For experimen-
tal uſe, it is therefore ſufficient to expoſe it

in

in thin ſtrata to the heat above mentioned
for five or ſix hours; but then it ought to
be ſifted through a fine lawn ſieve, in order
to ſeparate the half calcined lead that is ge-
nerally to be found in it; becauſe, ſome
particles of the metal, during the calcina-
tion, incruſt themſelves with the calx, and
eſcape the action of the air, and the ſparks
and coal duſt blown from the fire, fall on
the red lead during the proceſs, and revive
it ſuperficially wherever they meet it duly
heated. For this reaſon the quantity of
lead found in the beſt aſſays of ordinary
minium is variable, and is always greater
than that which the ſame red leads affords,
after it has been duly ſeparated from the
uncalcined part.

7680 grains, or 16 ounces of red lead,
yield 6835. 2 grains of lead in reduction; and
therefore 844. 8 grains are, in this tranſi-
tion, expended in the aerial and aqueous pro-
ducts of the proceſs; provided the reduction
is effected by the mere abſtraction of the mat-
ter which was imbibed during the calcina-
tion, and does not require any ſupply of phlo-

to

ſton towards the vivid lead. But if any of the phlogiſton employed in the revival, is imbibed by the metallic earth and retained in the lead, then the quantity of aerial and watery matter expelled from 7680 grains of minium muſt exceed 844. 8 grains, by this quantity of phlogiſton. Whether any, or what quantity of phlogiſton is expelled in the calcination of lead, is a queſtion which cannot yet be anſwered with preciſion. According to the opinion of Mr. Lavoiſier, who doubts of the exiſtence of phlogiſton, the calcination is effected by the mere entry, and combination of empyreal air with the whole matter of the lead, and the reduction muſt then be conſidered as the reſult of the mere abſtraction of this air. Mr. Kirvan, and moſt other able philoſophers, incline to the opinion that the greater part, though not the whole of the phlogiſton, is expelled in the calcination, and muſt be ſupplied again from a phlogiſtic ſubſtance during the reduction.

After due conſideration of the facts on which theſe different opinions have been founded,

founded, and of my own experiments, I am perfuaded that there is no good reafon for doubting the exiftence of phlogifton in this and other calcinable metals : but contrary to the opinion which I had entertained for many years, I am forced to adopt a new motion, that the air imbibed during the calcination of lead, unites with the phlogiftic and earthly matter, but expells little or none of theformer,and that little or,none of the phlo- gifton ufed in the reduction of minium,enters into, or contributes to the weight of the lead, but that it is almoft wholly expended in combining with the pure air of the calx and facilitating the expulfion of it.

Mr. Cavendifh's experiments fhew, that the gravitating matter of light inflammable air is phlogifton ; and the elafticity of this fluid, as well as the fire emitted during the union of its gravitating matter with empyreal air to form water, fhew its affinities to fire and empyreal air, and its aptitude to render thofe bodies combuftible, that hold it in combination. But as lead, like other metals, is combuftible, though

not

not in fo high a degree as zinc, and as it yields inflammable air in folution, though not fo copioufly as zinc or iron, it manifeftly contains phlogifton.

In the calcination of mercury in contact with emp. air, the latter is imbibed to a quantity equal to $\frac{1}{8}$ of the weight of the mercury, as Mr. Lavoifier has fhewn; but during the calcination nothing is emitted, and by the expulfion of the emp. air, and without any aid of phlogiftic matter, the mercury recovers its former metallic condition. Mercury in thefe experiments, and the noble metals in others, are found capable of imbibing air and becoming calciform without lofing any phlogifton; and all the appearances that have been thought to indicate the expulfion of phlogifton, during the folution of mercury and of the perfect metals, are fallacious, fince we know that the abftraction of the pure air from the acid employed, leaves the remainder of it in that ftate which we have been ufed to call phlogiftic, if not truly phlogifticated.

Lead

Lead diffufed in quick-filver, was found by Dr. Prieftly to phlogifticate atmofpheric air, and this is now known to imply that the lead imbibed empyreal air. Lead thus deprived of its aggregation, as it is in fufion, and freely expofed to pure air by agitation, becomes calciform whilft it imbibes the air, but emits nothing that glafs can retain, and confeqnently nothing of the phlogiftic kind.

Omitting other analogies and arguments, I am now to obferve that I have frequently endeavoured to calcine lead in contact with pure empyreal air, and to trace the phlogifton which is generally fuppofed to be expelled. But infurmountable difficulties attended every attempt, and this one particularly, that the calx firft formed precluded the air from the melted lead. So far however as the experiment fucceeded, I found an abforption of air, but no emiffion of any thing like inflammable air, nor of any notable quantity of water, which was indeed the expected product.

The freer and more rapid combuftion of zinc, indicates a greater quantity of phlo-

giston

gifton than is held in lead; and yet in burning zinc with pure air, I could never difcover, by any water feparable from the calx, that its phlogifton was difengaged or expelled.

I do not depend on the accuracy of thefe experiments, fo far as to affirm that no water is formed during the calculations of lead or of other metals, and that none of the phlogifton is detached in confequence of the formation of water; and I am aware, that in the calcination of thofe metals, particularly iron, which contain fome of our oily matter, fome fixable air is formed. But fince we are not authorifed by general analogy to fuppofe that lead lofes any notable quantity of its phlogifton by the calcination, fince even in folution it yields very little inflammable air; fince it does not detonate with nitre; and yet in the experiments above mentioned certainly imbibe air without yielding any quantity of phlogiftic matter or water that might deferve notice in the following experiments; I
fhall

ſhall not heſitate in aſſuming the lead of
7680 grains of minium at 6835, 2 grains,
and the other matter at 844, 8 grains : and
I may on the ſame grounds conſider the
reduction as effected by the mere expulſion
of aerial matter, without inducing any con-
ſiderable error in the following eſtima-
tions.

Dr. Prieſtley has ſhewn that lead expo-
ſed to the heat neceſſary for its compleat
fuſion, becomes lithrage in conſequence of
the emiſſion of a certain quantity of fix-
able air and of purer reſpirable air than
that of the atmoſphere. We now expreſs
the fact in other words and ſay, in the tran-
ſition to lithrage, red lead yields fixable
air and empyreal air mixed with phlo-
giſtic air in quantities which vary in the
ſucceſſive portions.

As the relative quantity of fixable air is
greateſt at the commencement of the pro-
ceſs, and gradually becomes leſs as that of
the empyreal air encreaſes ; and as this
and other metalic calces are always found

to

to hold empyreal air more obftinately than fixable or phlogiftic air, under ignition, we may fafely conclude that well fufed lithrage retains as much, or very nearly as much empyreal air along with a fmall quantity of phlogiftic air, as it exceeds its proper lead in weight.

By the affay I find that 7680 grains of lithrage yield 6924 of lead; and for the reafons above mentioned, this quantity of lead, together with 756 grains of empyreal and plogiftic air are fufficient to compofe 7680 grains of lithrage. According to this proportion, 6835. 2 grains of lead belong to 7581. 5 of Lithrage, as well as to 7680 grains of read lead, which has been found to contain this quantity of lead; and therefore the quantity by which 7680 grains of red lead exceed 7581. 5 grains of lithrage, in both of which the weight of lead is the fame, is the quantity of aerial matter which is ac-quired in the tranfaction of the lithrage to red lead, or of that which is expelled by fufing the red lead until it becoms lithrage, viz. 98. 5 grains, grains, of which I find

24 or lefs to be fixable air, and about 74.
5 to confift of empyreal air mixed with the
phlogiftic.

Before I difmifs this fubject I muft obferve
that lithrage by due calcination forms
red lead, and that I have feen this procefs
conducted on the great fcale of a manufac-
tory. I alfo can affirm from experience,
that by diftillation in glafs veffels, we can-
not difcover all that red lead emits during the
fufion and tranfition into the form of
lithrage, becaufe the veffel is always corroded
and perforated, before the central parts of
the charge can be compleatly melted. When
an earthen retort is ufed, the red lead cor-
rodes it and expels fome aerial matter from
it, and the part of the lithrage which in-
finuates itfelf into the pores of the veffel,
being heated more than the reft of the
charge, and employed in vitrification, lofes
fome of the proper air of lithrage. In
trials of this kind, the quantity of aerial
matter expelled during the fufion of
red lead into lithrage, is much greater
than in the former, and exceeds that which

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we

we have ſtated by eſtimation from the beſt aſſays.

On due conſideration of the nature of acids, and of the agency of empyreal air in metallic ſolutions and ſalts, and of the capacity of Phoſphorus to imbibe empyreal air; the experiments of Mr. Sage for the revival of metals from diluted ſolutions by phoſphorus, will be found to exhibit nothing repugnant to thoſe notions, although he gives a different interpretation of the phenomena. On the contrary we may diſcover in theſe precipitations the ſtricteſt conformity with our doctrine, ſince thoſe are the moſt conſpicuous and compleat, that are effected in the ſolutions of the perfect metals which loſe no phlogiſton by ſolution, or in the ſolutions of imperfect metals which yield the ſmalleſt quantity of inflamable air or phlogiſton in ſolution. Mr. Pelletier's experiment for precipitating reguline arſenic from the ſolution of acid of arſenic, by paſſing inflammable air through it, ſhews the agency of phlogiſton and empyreal air in the humid way, but does not prove that the privation

of

of the phlogifton reduces arfenic to an acid, or that the addition of frefh phlogifton is ne-ceffary to reftore the arfenic to the reguline ftate; much lefs does it ferve to fhew that lead in calcination lofes its phlogifton, or that calx of lead muft imbibe and retain the phlogifton of a reducing flux, before it can form lead.

In like manner Dr. Prieftly's ingenious experiment for reviving the calx of lead by light inflammable air, does not prove that any of the inflammable air unites with he lead, but fhews that the phlogifton of the inflammable air, ferves to extricate the empyreal air of the calx; and from the experiments of Mr. Cavendifh on empyreal and inflammable air, as well as thofe which follow, this extrication feems to be effected by the converfion of the empyreal air into water, by means of the phlogiftic matter of the inflammable air.

I mention thefe particulars in order to excite chemifts to a revifion of the phenomena on which the doctrine of phlogiftication and dephlogiftication of metals has been

founded,

founded, and to caution them againſt a pre-
cipitate condemnation of the notion that
lead loſes little or no phlogiſton in calcina-
tion, and that its calx imbibes as little from
any phlogiſtic body during the reduction. If
it were neceſſary to the purpoſes of our pre-
ſent enquiry that I ſhould exprefs my opini-
on, all that happens to lead during the calci-
nation and reduction, I ſhould ſay, the em-
pyreal air imbibed in calcination, is retained
along with the proper phlogiſton of lead, in
a ſtate approaching to that of water, in the
calx; and when bodies which can engage
this empyreal air, and form it into water or
fixable air, are duly adminiſtered, it is de-
tached, and leaves the proper phlogiſton of
the lead to be retained in its former ſtate
of combination. But if this is not ſtrictly
true in regard to the whole of the phlogiſton
of lead, it approximates the truth ſufficiently
for every purpoſe of our preſent enquiry.

S E C-

SECTION XIII.

Distillation of two pounds of red lead with half a pound of acetated vegetable alkali.

HAVING found by former experiments that concentrated acetous acid, whether directly mixed with a triple or quadruple quantity of lithrage or red lead, or applied to thefe by mixing the acetated vegetable alkali with them, revived the whole of the lead, and yielded at the fame time a great quantity of denfe inflammable air along with the fixable ; and wifhing to know, firft, the refult of trials with fmaller quantities of the acetous acid, and then the fmalleft quantity with which the reduction can be effected without wafte of inflammable air or phlogiftic matter, I proceeded as follows.

Two pounds averdupoife=13999 grains of fifted red lead and half a pound,=3499. 75 of my drieft acetated vegetable alkali, were ground together, and diftllied in a Chelfea retort. A more compact veffel was not neceffary, becaufe I did not intend to meafure the water, nor aim at any great accuracy

racy in regard to the quantity of elaſtic fluids. The meaſures in which theſe were received from the neck of the retort which was lengthened with a ſlender glaſs tube, contained each 8. 5 cubic inches, and the quantity of atmoſpheric air included in the neck of the retort and glaſs tube, was ſo ſmall as not to be regarded in ſo great a charge. The following table exhibits the meaſured bulks of the recent elaſtic fluids expelled during the proceſs. The firſt column ſhews what meaſures were actually examined; the ſecond repreſents the number of cubic inches of elaſtic fluid emitted at any period after the preceeding meaſure had been examined : the third ſhews the bulk of fixable air contained in the correſponding meaſure of the mixed airs, and the fourth ſhews the cubic inches of phlogiſtic and inflammable air which iſſued along with the correſponding quantity of fixable air. It is to be obſerved however, that the two laſt columns are formed on the ſuppoſition that the proportions of the elaſtic fluids to each other in the meaſures which were examined, did not differ much from thoſe of the intermediate portions which were not tried.

meaſure

Measures.		cub. in.	cub. in. of fix. air.	Cub. inches of inflammable and phlogistic air.
First 3	=	25.5	contained 6	inflammable air with some phlogistic
the 5th	=	17	8	inflammable with some phlogistic.
10th	=	42.5	21	inflammable with some phlogistic.
20th	=	85	42	
40th	=	170	85	
100th	=	510	255	inflammable air with some phlogistic air,
120th	=	170	113	
180th	=	510	340	
250th	=	595	396	
300th	=	425	282	
350th	=	425	282	inflammable with less phlogistic air
400th	=	425	212	inflammable with still less phlogistic air

These last portions issued slowly, and the retort was now heated to redness throughout.

450th		425	212	inflammable air with more phlogistic
455th		42.5	21.5	almost all phlogistic, and issuing very slowly
460th		42.5	28.5	almost all phlogistic, issuing very slowly

The heat of the charge was now sufficient to compleat the reduction of red lead

465th		42.5	30.5	all phlogistic, issuing quicker
470th		42.5	33.5	all phlogistic, issuing slow
475th		42.5	34.5	all phlogistic, issuing very slowly.

Total 475	4037.5	2402.5	1635	

Some watery vapour issued at every period of the process, exclusive of that which was quickly distilled at the commencement from the acetous salt; and of the mixed inflammable and phlogistic airs, about 200 cubic inches were phlogistic, and 1435 inflammable air,

When I had thus expelled 475 meafures or 4037. 5 cubic inches of elaftic fluid, and could obtain no more by a heat fufficient for the compleat reduction of red lead, and continued for more than 15 minutes, I quickly drew away the fire, in order to prevent the wafte of lead or erofion of the retort. When all was cooled, I found the alkali of the acetous falt lying over the lead, and tafting cauftic, but yet containing 174 grains of fixable air, and perhaps a little of the matter of the retort which the lithrage might have corroded before it was revived. The lead which formed a mafs at the bottom, together with the globules that adhered to the fides of the retort and could be collected, weighed 12439 grains; but as the lead ought to have weighed 12459. 1 according to former experiments, the fmall particles that could not be detatched and collected, weighed about 20 grains.

The lead of the minium employed in this experiment, being 12459. 1 grains, the whole of the aerial matter of the red lead was 1539. 9; and allowing 43 grains for

for fixable air, and 30 at the utmoft for phlogiftic air, for reafons which will appear hereafter, the empyreal air of the minium amounted to 1466. 9 grains. The fixable air of the meafures which were examined, was neceffarily imbibed into lime liquor, and thus meafured before it had cooled to the mean temperature, at which it would meafure lefs by a feventh, and weigh 1043. 372 grains. This and 174 grains retained in the alkaline falt make 1217. 372 grains of fixable air, to which the red lead alone contributed 43 grains; and thus the product of fixable air, from the acetous falt and empyreal air of the red lead, appears to be 1174. 372 grains.

The art of meafuring the phlogiftic air that was mixed with the inflammable air will be fhewn hereafter; here I am only to obferve, that the utmoft weight of the phlogiftic air of this experiment did not exceed 37. 7 grains, of which the minium alone might have yielded 30 grains, and the acetous falt furnifhed the remainder.

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The 1535 cubic inches of inflammable air were not of the heavieſt kind; but at a medium of the heavy which iſſued firſt and the lighter which was laſt expelled, the whole weighed about 300 grains.

In the acetous ſalt employed, the acid and water amounted to 1739. 396 grains, and the utmoſt quantity of acid, abſtracted from water, was ſcarcely 869. 698 grains. But of this quantity 7. 7 grains were of phlogiſticated air and 300 grains were expended in making inflammable air, and only 561.998 grains contributed to the formation of 1174. 372 grains of fixable air produced from the the acid, and the empyreal air of the red lead.

As the experiment and menſuration could not, for the foregoing reaſons, go further than to approximate the truth, I contented myſelf with the following inferences.

As the quantity of the acid which contributed to the formation of fixable air, ſcarcely amounted to 561. 9 grains, and the quantity of fixable air produced from this

and

and the empyreal air of the red lead, was
1174. 3 grains, this laſt air muſt have en-
tered into the compoſition of the fixable
air and formed one half of its maſs and
weight, or a great deal more. But ſince the
portion of acid thus expended, could yield,
by mere ignition and without the acid of
the empyreal air of the red lead, a great
quantity of fixable air, by reaſon of the em-
pyreal air which is a conſtituent principle
of acetous acid; the empyreal air muſt have
made near $\frac{2}{3}$ of the weight of the fiaxble air
found to have been formed of the mere acid
and the empyreal air of the red lead.

As the gravitating matter of empyreal air
makes about $\frac{2}{3}$ of the weight of the fixable
air, and as 1466. 9 grains of empyreal air
could not have been expended in making
1174. 3 grains of fixable air, of which a part
is certainly derived from the mere acetous
acid; and as none of the empyreal air iſſued
unaltered, and the whole of it was expend-
ed in forming new compounds; a conſider-
able part of it muſt have been employed in
the

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the formation of water, which iffued in vapour at every period of the procefs.

In this water we trace, in conformity to the experiments of Mr. Cavendifh, the phlo-gifton of that part of the acetous acid which was expended in the fixable air; and then infer that phlogifton is not a neceffary con-ftituent principle of fixable air.

Finally, fince there was a great furplus of inflammable air, but none of empyreal air, it is certain that the quantity of acid employed could have reduced much more red lead, and engaging more empyreal air, could have affifted in forming a much great-er quantity of fixable air and water.

SECTION XIV.

Diſtillation of eight ounces of lithrage, with two of acetous acid previouſly dephlogiſticated conſiderably by vitriolic acid; and formation of fixable air, from acetous acid and empyreal air, without ignition.

BY repeated digeſtions and diſtillations of acetous acid, from oil of vitriol, I endeavoured to diveſt it of ſuperfluous oil or phlogiſtic matter, as far as might be done without decompoſing the acid totally. Eight ounces averdupoiſe=3499.75 grains of lithrage were ground with four of water, and two ounces=874. 94 of this acid were gradually added.

A ſlight intumſcence enſued, and ſome acid vapour and elaſtic fluid eſcaped; but this laſt was chiefly the interſticial atmoſpheric air of the powdered lithrage, and the quantity of the former was too ſmall to be regarded on this occaſion. The heat did

not

not exceed 96 degrees; for the acid was added in fucceffive portions, and much weakened by the water previoufly mixed with the lithrage.

In the courfe of two hours, during which the mixture was frequently agitated and ground in a porcelain mortar of Mr. Wedgwood's excellent manufacture, the lithrage became white, and indeed formed white-lead. A Wedgwood retort, which could retain elaftic fluids, or any charge, better than the common Chelfea retorts, was charged with the mixture, fo that none of it was left adhering to the neck; and my aparatus for faving the condenfible vapour and the elaftic fluids, being fitted to it, the diftillation was carefully conducted, but at the fame time as quickly as the menfuration of the elaftic fluids would permit.

When the atmofpheric air included in the retort and receivers, was almoft all expelled, along with the four ounces of water ufed in the mixture, the fubfequent products were meafured thus.

cub.

cub. in.	fixable.	phlogistic	
firſt 8	4	4	———————
next 8	6	2	———————
8	7	1	———————
16	15	1	phlog. and inflam.
16	15	1	———————
16	15	1	———————
16	15.2	8	———————
16	15.2	8	inflammable with
16	15.2	8	ſome phlogiſtic.
16	15.2	8	———————
8	7.6	4	———————
80	75.6	4.4	———————
80	75.6	4.4	———————
80	75.6	4.4	———————
80	77.8	2.2	———————
80	77.8	2.2	inflam. with
80	77.8	2.2	very little of the
80	77.8	2.2	phlogiſtic.
80	75.6	4.4	———————
80	75.6	4.4	———————
80	71.2	8.8	all imflam.
80	71.2	8.8	———————
40	35.6	4.4	———————
total 1064	997	66.4	———————

The

The laft portions iffued very flowly, and the emiffion ceafed when the charge was heated fufficiently for the reduction of lithrage; and in the middle and latter meafures, the elaftic fluids carried with them fome aqueous vapour.

Neither the firft, nor any fubfequent portion of the water collected during this diftillation, fhewed any fign of acid; but it was ftrongly impregnated with ethereal oil of acetous acid, fome of which floated diftinct on it, and fome was expended in greafing the Recipients. By a trial to be related hereafter, I found that the quantity of oil was not lefs than 10 grains.

The quantity of water was greater than was employed in the experiment, including that of the acid; but the encreafe was not meafured, becaufe an earthen retort admits of no accuracy in this particular, unlefs it be of true porcelain well glazed.

On opening the retort, a large mafs of lead was found at the bottom, which with the globules collected from the fil s, weighed

Q   3125 grains;

3125 grains; and from the appearanc of the fmaller globules which I could not detach without wafte, it was manifeft that the whole of the lead was revived, and that if there had been no wafte, it would have weighed 3155. 242 grains, which is the whole quantity of lead obtainable from the 3499. 75 of lithrage ; the aerial matter of which amounts to 344. 506 grains. By firing the mixture of inflammable and phlogiftic air, with as much empyreal air as was barely fufficient for the combuftion of the inflammable part, and meafuring the bulk of the refiduary phlogiftic air, I found that the 66. 4 cubic inches of the mixed airs confifted of 20 of phlogiftic air and 46. 4 of inflammable air.

Deducting 7. 54 grains which is the weight of the 20 cubic inches of phlogiftic air, from 344. 506 the weight of all the aerial matter of the lithrage, we find the empyreal air of the lithrage to be 336. 966 grs.

Of the inflammable air which iffued at the commencement of the procefs, a cubic inch weighed 260 ; but a cubic inch

4   of

of that which was laſt expelled by the greater heat, weighed leſs than 2. grs. and by the noticed decreaſe of the ſpec. gravity, I was aſſured that the mean weight of 23 grains in a cubic inch might be aſſumed in computation, and that the 46. 4 cubic inches weighed 10. 672.

The inflammable and phlogiſtic airs were meaſured at the due temperature; but the fixable air, being meaſured as it iſſued warm from the extremity of the recipient, contracted in cooling to the mean temperature, by one fifth of its bulk, and in this laſt ſtate would weigh 454. 632 grains.

According to Mr. Kirvans eſtimation; the mere acid is to the concomitant water of concentrated acetous accid, nearly as 19. to 49: But I have reaſon think we are leſs liable to error in ſtating them as 20 to 48; and by this rule, the acid employed, amounting to 874. 94, contained of mere acid and its phlogiſton 257. 335 grains, and of water 617. 604 grains.

As

As the inflammable air and oil were derived from the acetous acid alone, and weighed 20. 672 grains, the quantity of the mere acid otherwife expended was 236. 663 grains.

The phlogiftic air inflammable air and oil being thus accounted for, the empyreal air of the lithrage, weighing 336. 966, with 236. 663 of the acetous acid abftracted from water, were expended in the formation of 454. 632 grains of fixable air, and a quantity of water not afcertained by direct menfuration, but which muft be nearly 118. 997 grains, becaufe this and the fixable air make the weight of the empyreal air and efficient acid laft mentioned.

Now it is to be confidered that the acetous acid, when by mere ignition a part of it is converted into inflammable air and oil, yields a great quantity of fixable air, which for the reafons formerly ftated, is proportionate to the quantity of empyreal air which the acid contained. In this cafe, the quantity of fixable air producible from the mere acid,

acid, by heat alone, is not lefs than one third of its weight; and therefore, without any aid of the empyreal air of the lithrage, the whole of the acid employed in the experiment, may be faid to have yielded out of its proper matter 85. 778 grains of fixable air, and the quantity of this laft which was not merely extricated, but formed with the affiftance of the empyreal air, was about 368. 854 grains; for this with the laft mentioned proper fiaxble air of the acetous acid, makes the whole of the fix-able air obtained.

Deducting the inflammable air and oil, the quantity of the mere acid otherwife expended, appears to be 236. 663 grains ; and deducting from this the proper fixable air of the acetous acid 85. 778 grains, we find the quantity of the mere acetous acid, which was expended in the formation of fixable air with empyreal air, and in the formation of water and revival of the metal, to be 150. 885 grains. Thus it appeared that the utmoft quantity of acid matter

derived

derived from the acetous acid, in 368. 854 grains of the fixable air did not amount to 150. 885 grains, but fell short of this weight by as much as the proper fixable air of the acid exceeded 85.77 grains, and by the whole quantity of phlogiston expended in the formation of water. Deducting this phlogistic matter, which could not be less than 17 grains, the acid matter in 368. 854 grains of the fixable air, did not amount to 133.885 grains. Hence it was inferred that when the acid matter of acetous acid is employed *in excessive quantity* to form fixable air with the empyreal air of lithrage, the fixable air may consist of a little more than one part of the acid matter combined with two of the empyreal air. By a more accurate estimate of the fixable air taken at 85 grains, it is most probable that the proportions would be found to be accurately two to one, provided fixable air, like other acids, may not subsist with various proportions of the empyreal air.

In this view of the subject, I could not perceive that the lithrage imbibed any considerable quantity of phlogistic matter from the

the acid employed; for admitting that in the fixable air formed, the quantity of matter derived from the acetous acid, was no more than one third of the weight of that fixable air, and confequently only 122 grains inftead of 133 as it was ftated; no more than 11 grains of the acid employed remain unaccounted for; and it is by no means probable that the phlogiftic matter appertaining this quantity, could have produced any confiderable effect on eight ounces =3499.75 grains of calx of lead, if it had been really dephlogifticated during the calcination. It was therefore inferred that lead lofes little or none of its phlogifton in calcination, and imbibes none during the reduction; but that in this latter procefs, the calx of lead is divefted of the empyreal air together with the fmall portion of phlogiftic air which it imbibes in the calcination.

From fome of the phenomena of this experiment, I fufpected that the acetous acid could be totally converted into fixable air and water, by combining with empyreal

Q 4

air

air, and without the affiftance of fire. I therefore triturated this acid diluted with a quadruple quantity of water, with lithrage in various proportions; and found that the quantity of mere acid that was barely fufficient, by frequent trituration, to make the lithrage look white in the courfe of two days, united with the empyreal air of the lithrage, and in the new forms of fixable air and water, formed with the lead a calciform mafs, which after being duly dried and powdered, yielded no acetous acid either in diftillation or in folution in vitriolic acid, but afforded fixable air in abundance, and mixed only with a very fmall quantity of inflammable air.

The weight of the fixable air was always twice greater than that of the mere acid abftracted from water; and in fome experiments it was ftill greater. Thus it appeared that fixable air may be made of its conftituent principles, without the aid of ignition, when they meet unreftrained by any counteracting power; and that when

acetous

acetous vapour or denfe inflammable air meet empyreal air without forming fixable air, the counteracting agent is no other than the matter of fire, which caufes the repulfion of their parts, and confequently the elafticity of thefe fluids.

S E C-

SECTION XV.

Reduction of lithrage and red lead by acetous acid, and the products.

TO prevent the waste of acetous acid during its action on lithrage, I poured two ounces troy=960 grains of the strongest concentrated vinegar recently procured from acetated vegetable alkali and retaining all its phlogiston, into four ounces=1920 grains of distilled water and adding this gradually to 14 ounces=6720 grains of lithrage, I ground them together. The heat of the mixture did not exceed seventy degrees, and little or nothing was emitted, except the interstitial air of the lithrage powder, which caused a slight intumescence.

The mixture was at first quite soft; but after being ground for about half an hour in a porcelain mortar, it grew stiff, and in two hours it was sufficiently dry to be cut

into

into flices which were rather friable than plaftic. The water then feemed to have been engaged in the faline mafs, as the proper water of its cryftals.

Having obferved in former experiments that this acid required a good deal of time to combine intimately with the lithrage and to form a mafs refembling white-lead in colour, I left it clofely covered for 24 hours, and then found it fo hard and dry as to require fome force in cutting out that part which had not formerly been loofened from the mortar. The whitenefs which appeared in the fuperficial parts on the firft action of the acid, gradually improved as the mafs dried, and at laft was almoft equal to that of white-lead, with fcarcely any appearance of the lithrage colour. It was then diftilled in a Wedgwood retort, and the products being meafured and examined at fhorter intervals than thofe expreffed in former experiments, were ftated thus.

The fixable air weighed   658   grains
The phlogiftic air   20
The inflammable   3

No

No oil appeared in this experiment, and the quantity of water was not afcertained, becaufe in the quick emiffion of the elaftic fluids a great quantity of the watery vapour was wafted along with them, and more was condenfed in the meafures than remained in the recipient.

In the revival of lithrage by means of acetous acid, charcoal, and other fubftances, I had repeatedly obferved that the quantity of phlogiftic air was not as that of the phlogiftic matter employed, but as the quantity of the calx reduced to lead, and concluded that the phlogiftic air proceeded from the lirhrage chiefly. By experiments of this kind I am now perfuaded that in the calcination or fcorification of lead, the calx imbibes not only the empyreal air, but fome part of the phlogiftic air of the atmofphere, and that the quantity of this laft varies in different parcels of lithrage, from ten grains in 16 ounces to 20 or more, which laft was the quantity in this diftillation.

In

In the retort I found a mafs of lead co-
vered with fmall grains and globules of
of the fame metal, without any perceptible
admixture of unreduced lithrage, all to-
gether weighing 6034. 5 grains. The
lead which adhered in thin plates and fmall
globules to the fides of the retort, and could
not eafily be detached or weighed, was
eftimated at 24 grains; becaufe this quan-
tity with the former makes 6058. 5 grains,
the proper lead of the 14 ounces of lith-
rage.

By the rule formerly eftablifhed the aeri-
al matter difcharged during the reduction
of 14 ounces of lithrage, amounted to 661
.5 grains; and as 20 of this quantity con-
fifted of phlogiftic air, the empyreal air
weighed 141. 4 grains. But as none of this
efcaped unaltered, it muft all have been ex-
pended in the formation of fixable air and
water; and as none of the acetous acid efcap-
ed unaltered, that part of it which was not
neceffary towards the formation of water,
was expended in the fixable air; and the
greater part, if not all the phlogifton of the

acetous

acetous acid, except that of the inflamma-
ble air which efcaped, appears to have been
employed in the formation of water.   As
this acetous acid was of the ftrongeft kind,
and neither aerated nor deprived of any oily
matter by diftillation with vitriolic acid
we cannot, confiftently with the experiment
of the laft fection, eftimate the quantity of
mere acid and phlogiftic matter at lefs than
293 grains, or the water at more than 667.
But as three grains of the former were ex-
pended in inflammable air which efcaped
the lithrage, 290 grains of mere acid and
641. 5 grains of empyreal air were expend-
ed in the formation of 658 grains of fixa-
ble air, and of water whofe quantity was
273, provided no part of the phlogiftic mat-
ter of the acid entered into the lead.

This quantity of water required 39 grains
of phlogifton, which is almoft a feventh
part of the acid; and about one fourth of
that part of the acid which forms inflam-
mable air by mere ignition : and in this
view of the fubject we find no reafon for
fuppofing that any of the phlogifton of the
acid entered the lead or fixable air, or that

it was otherwife expended than in the for-
mation of water.

If the quantity of water amounted to
273, not lefs than 234 grains of empyreal
air, were expended in the formation of it,
and the remainder of the empyreal air, viz.
407. 5 grains, was employed in the forma-
tion of fixable air, the quantity of which
would be 611. 2 grains, provided the em-
pyreal air be to the other matter of fixable
air as two to one. But the whole of the
fixable air produced was 658 grains, if not
more ; and this excefs is to be imputed to
the fixable air which the acetous acid alone
is capable of producing when ignited, by
reafon of that empyreal air which is a con-
ftituent principle of this as well as of other
acids.

In the hafty diftillation of recent mix-
tures of lithrage and acetous acid, I have
often had a greater wafte by the efcape of
inflammable air, and fome part of the lith-
rage remaining unreduced, whether the
quantity of acetous acid was greater or lefs
than

than is here reprefented; and in repeated experiments I have obferved that the intended expenditure of the acid was beft effected, by finking the bottom of the retort an inch or two in the fand-bed of a reverberatory furnace, and thus caufing the fire to act from above downwards.

Having mixed concentrated acetous acid duly diluted with water, with red lead in various proportions, and heated thefe mixtures in the manner already defcribed, I found the products and phenomena to differ from thofe lately mentioned in nothing but what might have been expected from the greater quantity of phlogiftic and empyreal air contained in red lead with the portion of fixable air already noticed.

The quantity of inflammable air was fmalleft when the weight of the red lead was to that of the acid as 16 to 2, and then did not exceed five grains. The greateft quantity of lead reduced by two ounces of the acid did not exceed eleven ounces and a quarter; and whenever more red lead

was

was ufed than the acid could reduce, the fu-
perfluous part formed lithrage by the fu-
fion, and emitted the quantity of fixable
phlogiftic and empyreal airs which it ufual-
ly yields in the tranfition to lithrage, as we
have ftated in the 12th fection.

In thefe experiments it always appeared that
much more acid was neceffary towards the
revival of a given weight of lead from red
lead, than was required in precipitating the
fame quantity from lithrage : and as the
calx which contained moft air and leaft
lead, required the greater quantity of acid
for its reduction, I had this additional
ground for the opinion that the acetous acid
acts rather by facilitating the expulfion of
aerial matter from fuch calces, than by
contributing any thing confiderable towards
the mafs or weight of the revived lead.

It is fcarcely to be doubted that this doc-
trine is applicable in other metalic reduc-
tions effected by fuel or fubftances contain-
ing our oily or coaly matter ; and that the

R   quantity

quantity of empyreal air in any calx, may
be determined by the quantity of fixable
air and water emitted during the fufion
with fuel previoufly divefted of fixable air
and water.

SECTION XVI.

Distillation of lithrage with acetous acid, with a view to the menfuration of the water formed, as well as to the other products.

HAVING obferved that water thrown on a hot earthen retort of the kind ufually fold in London, is abforbed into its whole fubftance; and that the part of the water which penetrates towards the internal furface, is expelled through it, into the annexed receivers, where it may be condenfed; I could not rely on any experiments made in fuch retorts, in regard to the aqueous products of the charges, fince it was to be apprehended that the water, impelled by the excentric preffure of vapour and elaftic fluids, might be expelled through the retort much quicker than it is found to enter when poured on the heated veffel: and as the more compact retorts of Mr. Wedgwood might be fufpected of imbibing fome

water,

water, and perhaps of tranfmitting it, be-
caufe they were not glazed; I made the
following experiment, with a view chiefly
to the water producible in confequence of
the union of the empyreal air with the
phlogiftion of the acid.

I mixed an ounce=480 grains of my
ftrongeft concentrated acetous acid with
four ounces=1920 grains of water, and
this I ground ten ounces 4800 grains of
lithrage. Having ufed the precaution of
tying a bladder over the veffel in which
the mixture was made, I was affured that
there was no wafte by the evaporation of
the acid, or the emiffion of any elaftic
fluid different from the interfticial air of the
lithrage, which the water alone would have
expelled; and I could not perceive that
the mixture was difpofed to drink in any
of the atmofpheric air included in the blad-
der.

In this confined fituation, it became
confiftent enough in 7 or 8 hours, to be
formed into pellets; but to make them pafs
freely

freely and without waste through the long
and slender neck of a glass retort, I left them
exposed to the air for 24 hours, in which time
they dried sufficiently, and lost 168 grains
of the water employed. The glass retort,
well coated, was filled to the helm with
these pellets, and heated on the sand bed of
a reverberatory furnace, from which its neck
extended two feet, before it entered the
receiver, to which it was well fastened with
glue lute. The atmospheric air of the
vessels is not regarded in the following
account, because it passed off with the wa-
tery vapour, before any considerable quan-
tity of fixable air was emitted.

cub. in.	fixable	phlogistic
1 ft. 25	13	12 with very little
next 25	19.5	5.5 ditto [inflam.
25	21.5	3.5 ditto
25	22.1	2.9 ditto
25	23.3	1.7
25	23.3	1.7 ditto

At this period the retort was not in the
least reddened in any part.

Cub. in.

cub. in.	fixable	phlogiftic
25	23.7	1.3 ditto
25	24.1	9
25	24.1	9 ditto
25	24.2	8
25	24.2	8 with more in-
25	24.5	5 (flam.
25	24.6	4
25	24.6	4

The mixed airs as they iffued fmelled like acetous Ether or nit Ether, and water trickled flowly all the time from the neck of the retort, but there was no appearance of oil.

| 25 | 24.6 | 4 ditto |

The retort was not yet reddened.

25	24.6	4 ditto
25	24.6	4 ditto
25	24.8	2
25	24.8	2 ditto
25	24.9	1

The retort was now red hot, and water iffued flowly.

| 25 | 24.9 | 1 |
| 25 | 25 | 0 |

The

The retort was hotter than would be ne-
ceſſary for the fuſion of lithrage, during
the emiſſion of the two laſt meaſures, which
was very ſlow; and no more could be pro-
cured by an encreaſe of heat until the retort
was ready to melt, when I quickly with-
drew the fire, and left the veſſels to cool
gradually. The elaſtic fluid left in them
was fixable air and meaſured fifty cubic in-
ches, which with the former quantity make
600 cubic inches.

Of this bulk, the fixable air, which was
meaſured as it iſſued, made 564. 9 cubic
inches; but at the mean temperature it
would have meaſured 484. 2 cubic inches,
weighing 275. 994 grains.

Of the phlogiſtic and inflammable air,
meaſured at the mean temperature, after
the fixable air was withdrawn from them,
there were 35. 1 cubic inches at leaſt, and
by the method already deſcribed, I found
the bulk of phlogiſtic air to be about 30.
1 cubic inches, weighing 11. 347 grains,
and that of the inflammable about 5 cubic

inches

inches weighing at the utmoſt 1. 305
grains. The diſtillation was ſlowly and
ſteadily performed, and laſted four hours in
the month of Auguſt 1783, from the time
when the fixable air appeared until the fire
was withdrawn.

The water condenſed in the recipient
was not in any ſenſible degree oily, or im-
pregnated with acetous acid, but ſmelled,
not unpleaſantly of the inflammable air. It
was quite limpid, and including ten grains
which adhered to the veſſels, it weighed
2107 grains. Of the water mixed with the
acid and lithrage, only 1752 grains were
included with the charge, becauſe 168
grains had exhaled. In the acid employed
the water did not exceed 335 grains, the
mere acid being eſtimated at 145 grains in
480 of this concentrated acetous acid. The
whole of the water therefore included
with the charge amounted to 2087 grains;
which is leſs than the quantity found in
the receiver, by twenty grains. From this
alone it appears that a conſiderable quantity
of water was actually formed, and conſe-

quently

quently that fome of the empyreal air of
the lithrage, with phlogifton from the ace-
tous acid, was expended in this way : And
the emiffion of water, during the whole of
the procefs, and long after the charge had
fuftained a heat fufficient for the fufion of
lithrage, cannot be fatisfactorily accounted
for on any other ground. But it is further
to be obferved, that a great quantity of wa-
tery vapour was wafted out of the receiver,
along with the warm elaftic fluids ; for
whenever I applied a cold and dry veffel to
receive them, it was bedewed, and plainly
fhewed that much more water was really
formed in the manner already mentioned,
than was afcertained by direct menfuration.

On opening the retort, I found fome of
the pellets retaining their figure ; but thofe
which lay contiguous to the veffel and
were heated more, were altered in this re-
fpect. The former exhibited in a diftant
view, a fallow green colour ; but on clofer
infpection, this appeared to be compounded
of the dark blue of minute globules of lead,
interfperfed with the yellow of lithrage.

The

The other pellets funk into a mafs confifting of large globules of lead bedded in melted lithrage. A more compleat fufion of the lithrage and fubfidence of the lead, in the heat above defcribed, thus appeared to have been prevented by the expenditure of the fire in the formation of the elaftic fluids continually emitted from the charge.

The whole mafs, carefully feparated from the glafs, weighed 4560 grains, and therefore the lithrage which was reduced to lead yielded 240 grains of aerial matter; for this lithrage by the mere expofure to the like heat was found to yield little or nothing.

Of the 240 grains, 11. 347 may be confidered as the weight of phlogiftic air; and 228. 653 grains, is the quantity of empyreal air.

Out of 145 grains of mere acid, 1. 305 were expended in inflammable air; but in confideration of the fmell of the water, we may ftate the expenditure at 2 grains; and
then

then it will appear that from 143 grains of mere acid and 228. 6 of empyreal air, 275. 9 of fixable air were formed, and the water compofed at the fame time was not lefs than 95. 7 grains, although fcarcely a fourth part of this quantity was faved in the recipient.

According to this eftimation 82 grains of the empyreal air were expended in forming water, and the remainder of the empyreal air=146.6 grains, was employed in the formation of fixable air. But if the materials of fixable air be to each other in the proportion laft ftated, this quantity of empyreal air was expended in forming 219. 9 grains of fixable air, and the acid furnifhed the remainder, by virtue of its proper empyreal air.

Now, in comparing the products of different experiments, and allowing duty for inaccuracies, we find ftrong grounds for fufpecting that the proportion of empyreal air to the other matter in fixable air, is variable; and that this, like other acids, may fubfift

with

with different dofes of empyreal air, and may vary in this refpect, according to the circumftances under which it is formed. This is, at leaft, a confideration not to be neglected by future experimenters.

SECTION XVII.

Regulization of Arfenic by acetous acid.

THE flame of burning regulus of arfenic, and the facility with which it enters into combuftion in a moderate heat, impreffed me with the opinion that it contains more phlogifton than is held in lead or metals which exhibit no flame or vivid fparks during the calcination, and that if there is any lofs of phlogifton during the calcination of either, that of the arfenic muft be greateft. In this cafe, the calx of arfenic would not only require a greater quantity of phlogifticated acid for its reduction to the reguline ftate, but would yield a fmaller proportion of fixable air; fince the fixable air which is formed by the affiftance of empyreal air in reductions, is five or fix times greater in quantity than that which the acetous acid alone can yield by ignition: But if, on the other hand, the calx of arfenic

<div align="right">fhould</div>

fhould be found to require but a fmall
quantity of acid, in order to form the com-
buftible regule ; and if the quantity reduced
to the reguline ftate fhould be proportion-
ate, rather to the quantity of empyreal air
expelled from it, than to the quantity of.
phlogifton derived from the acid, this
would fhow that this regule lofes little or
none of its phlogifton during the combuf-
tion, and receives as little in the reduction.

With thefe views, and not without ex-
pectation of fhewing the great quantity of
empyreal air which this regule imbibes
during the deflagration, without any
confiderable lofs of phlogiftic matter, and
alfo of proving the greater affinity of empy-
real air to the acid of fixable air, than to
that of arfenic, I made the following expe-
riment.

I mixed 1749. 88 grains of my acetated
vegetable alkali, whofe acid and water
weighed 869. 715 and its alkali 880. 165
grains, with 6999. 5 grains of cryftaline
white arfenic, and gradually heated the

mixture

mixture in a glafs retort placed in a fand
pot and connected with the ufual appara-
tus for meafuring the elaftic fluids. Re-
jecting the atmofpheric air of the veffels, I
ftated the product thus.

cub. in.	fix. air	phlogiftic	
firft 9	1.8	7.2	
next 9	4	5	phlogiftic
9	4.5	4.5	ditto
9	5.5	3.5	ditto
9	6	3	ditto
9	6.5	2.5	ditto
9	6.8	2.2	ditto
9	7.2	1.8	ditto
9	7.6	1.4	ditto
9	8	1	ditto
45	43	2	ditto
45	43.5	1.5	ditto
90	88	2	ditto
90	88.5	1.5	ditto
90	88.5	1.5	ditto
90	88.6	1.4	ditto
90	88.4	1.6	ditto

90

90	87	3 ditto
90	85.5	. 4.5 phlogiftic
90	84.5	5.5 ditto with very

[little inflam.

Water ftill continued to trickle from the retort, and rolled down in round globules over a thin coat of reddifh brown arfenical fublimate, which lined the lower part of the neck of the retort through its whole length, and was afterwards found to be regulus of arfenic chiefly. The elaftic fluids carried with them a denfe white vapour which foon condenfed into white, and partly into reguline arfenic; but ftill fo much arfenic was permanently retained, that the elaftic fluid fmelled horribly arfenical.

90	84.3	5.7 ditto
90	84.3	5.7
90	84.2	5.8 ditto
90	84.1	5.9 ditto
90	84	6 ditto
90	84	6 ditto
90	84	6 ditto
90	84	6 ditto

90	84	6	ditto
90	84	6	ditto
450	420	30	weakly inflam.
90	84	6	ditto.

The emiſſion of air being very ſlow, al=
though the heat was encreaſed until the
retort was red hot, very little more was to
be expected, and I withdrew the fire to
ſave the retort and its contents.

Of the air left in the retort and recipi=
ents 33. 6 were fixable air and 2. 4 cub.
inches were phlogiſtic mixed with a very
ſmall quantity of inflammable air. The
ſum of the cubic inches of warm airs

was   2376
of warm fixable air   2221. 9
the phlog. and inflam. air at the
    mean temperature meaſured   154. 1
the fix. air contracted in cooling
    by ⅛ of its bulk and meaſured 1851. 584
weighing   1055.403 gr.
The phlogiſtic air weighed   56 grains
and the inflammable air about   2 grains.

The water faved in the recipient weighed 460 grains, although the acetous falt, which was dry, could not have yielded more than 430. 7 grains. Of the water formed during this procefs, we may fay that about 30 grains were faved: but a much greater quantity was manifeftly wafted away along with the fixable air, which iffued warm, and depofited moifture, as often as the fucceffive portions of it were tried by cooling them in dry veffels.

In the retort I found 3900 grains of reguline arfenic fublimed and adhering near the helm. The neck of the retort was alfo lined with the like matter in a powdery form, which with the fmall portion blown forth into the receiver, weighed 37 grains: and the whole of the reguline arfenic did not exceed 3937 grains.

The mafs remaining at the bottom of the retort fhewed a granuilar texture, like that of fine fugar, and had a pearly whitenefs. It appeared to have been in a ftate

of

of perfect fnfion, and tafted like neutral ar-
fenical falt. The retort fuffered fome fu-
perficial erofion at the bottom. I feperat-
ed this faline arfenical fubftance into two
parts; one confifting of the calx of arfenic
unaltered, the other of fuch arfenical falt
as I had often made by digefting white ar-
fenic with cauftie vegetable alkaline lixivi-
um ; for it became liquid in a boiling heat,
plaftic and repoy in a weaker heat, and
quite hard, like glue, in cooling.

Thus it appeared that the acetous acid
was expended in reducing a great part of
the arfenic to the reguline ftate, and in ex-
tricating its aerial matter, which the quan-
tity of fixable air fhewed to be of the em-
pyreal kind. But as no empyreal air was
emitted uncombined ; and as the refiduary
arfenic, whether we confider the portion
combined with the alkali, or that which
was only detained, remained unaltered, we
may conclude that this part contributed
little or nothing towards the elaftic fluids ex-
pelled from the charge, and that 3937 grains
of regule of arfenic, in the tranfition to calx

of

of arfenic or white arfenic, imbibe about 56 grains of phlogiftic air, and as much empyreal air as is neceffary for forming 1055. 4 grains of fixable with the quantity of acetous acid here employed. This quantity was eftimated at 439 grains of mere acid abftracted from water; but as two grains were expended in inflammble air, only 437 had been employed in forming 1055. 4 grains of fixable air.

In confideration of the fixable air alone, 3937 grains of regulus yielded 618. 4 grains of empyreal air; but in confideration of the water formed, we muft allow a much greater quantity of empyreal air to white arfenic, together with the proportion of phlogiftic air already mentioned. If the proportion of aerial to reguline matter, were the fame in white arfenic and in red lead, the regulus in this experiment could have held or yielded only 486. 5 grains of air.

This loofe comparifon of the neceffary quantities of acetous acid, and of the aeri-

al

al matter extricated during the converfion of white arfenic into combuftible regulus, and calx of lead into metal, and the expenditure of the phlogifton in forming water, in both inftances, are fufficient to fhew that the alteration is effected in one as well as in the other by the abftraction of aerial matter; fince the expenditure of the phlogiftic body is as the quantity of aerial matrer extricated, and not as the weight of the reguline or metallic mafs produced in thefe experiments. For thefe reafons, the gradations we obferve in the combuftion of metals, regulus of arfenic and phofphorus, depend rather on the quantity of the gravitating matter of empyreal air, which they refpectively imbibe, and of the fire confequently extricated, than on any circumftance of dephlogiftication. Finally, fince acetous acid duly applied is as effectual in the formation of phofphorus and fulphur, with their refpective acids, as in that of regulus of arfenic, and in metallic reduction, the attraction of empyreal air to the acid matter of fixable air, is of the ftrongeft kind, and muft render the decompofition of fixable air excedingly difficult.

SEC-

SECTION XVIII,

Products of 16 ounces of lithrage and one of charcoal, during the reduction.

SELECTED pieces of well burned charcoal of oak were put into a deep earthen veſſel called a long pot, and covered to the depth of an inch with powdered charcoal. The pot was well cloſed with a luted cover, and kept two hours in a heat ſufficient to melt ſilver. Then it was placed in ſuch a manner that the powder might remain red hot for ſome time after the pieces next the bottom had cooled. This was done, in order to perfect the charring, to make the lower pieces imbibe only the proper inflammable air of charcoal, ſince they muſt imbibe ſomething in cooling to prevent their abſorbing atmoſpheric air, and eſpecially to prevent any of the empyreal part of atmoſpheric air from entering into them,

ſome

Some of these pieces being briskly reduced to fine powder in a covered mortar, 480 grains of this powder were immediately mixed with 7680 grains of powdered lithrage, and instantly charged into a coated glass retort, for in other experiments I had observed that such charcoal, more freely and longer exposed to the air in powder, drinks in water from the atmospheric air, and that 480 grains of the powder could imbibe four or five grains from the air in half an hour.

The retort being placed in a reverberatory furnace, with its bottom sunk two inches in the sand, the fire was made to act slowly on it from above downwards. The products during the reduction, exclusive of the dilated air of the vessels, were noted as follows, the fixable air having been measured warm, the rest at the mean temperature.

cub. in.	fix. air	phlogistic.
17	5	12 ditto
17	11	6 ditto

S 4   17

cub. in.	fixable	phlogiftic
17	16.5	0.5 ditto
17	16.7	0.3 dirto
17	16.8	0.2 ditto
17	16.8	0.2 ditto
17	16.8	0.2 ditto

Thirty grains of water are now faved in the recipient.

17	16.8	0.2 ditto

The retort is almoft red hot.

17	16.8	0.2 ditto
17	16.8	0.2 ditto
85	84.6	0.4 ditto

The Retort is red hot throughout.

85	84.7	0.3 ditto

Water drops flowly from the nozzle of retort, and the quantity now collected in the recipient is about 40 grains.

85	84.9	0.1 ditto
85	84.9	0.1 ditto

The

The elaftic fluids now iffue very rapidly.

cub. in.	fix air	phlogiftic
85	84.9	0.1 ditto
85	84.8	0.2 ditto
85	84.8	0.2 ditto

The elaftic fluids iffue by pulfes and the watery vapour is vifible at its exit from the nozzle of the retort.

85	84.7	0.3 ditto
85	84.7	0.3 ditto
85	84.6	0.4 ditto

The elaftic fluid continues to iffue rapidly, and to carry watery vapour, and more water is collected in the recipient, amounting in the whole to feventy grains or more.

85	84	1	{ containing a little inflam.
85	83	2	{ equal parts of phlog. and inflam.
85	.79	6	almoft all inflam.
85	74	11	ditto
85	68	17	ditto
34	22	12	all inflam.

In

In this laft is comprehended the elaftic fluid left in the veffels. Although the heat was greatly augmented, the emiffion was now fo flow, that nothing more could be expected by any degree of heat that the retort could fuftain; I therefore withdrew the fire. The cubic inches of hot fixable air were 1407. 6; of phlogiftic and inflammable airs 71. 4, of which 44 were inflammable and 27. 4 phlogiftic air.

By cooling feveral portions of the fixable air, at different periods of the procefs, and allowing . 57 gr. to each cubic inch of it in the temperate ftate, I eftimated the weight at 650 grains. The 27. 4 cubic inches of phlogiftic air weighed 10. 329 gr. But as it had been exceffively agitated with water unufually thickened with lime, I fufpected that fome of it was entangled in the lime, and had eluded the menfuration. It is therefore expedient to ftate the phlogiftic air at 20 grains, fince this will better accord with other experiments, and will create the leaft error here.

The

The inflammable air meafuring 44 cubic inches, was eftimated at feven grains, for it was lighter fpecifically than any that had been expelled from acetous compounds.

The elaftic fluids, as they iffued, fmelled agreeably of fixable air, and of nothing elfe until the inflammable air appeared, which imparted its peculiar fmell to the fixable air that accompanied it. There was not a particle of oil; and eighty grains of water were faved in the recipient, although a confiderable quantity was certainly wafted away along with the fixable air; for dry meafures were foon bedewed with it in cooling,

When the helm of the retort was broken off, the globular part with its coating appeared like an earthen veffel well glazed on the infide. The glafs was not much corroded, but was indented, near the upper part of the charge, by maffes of lead: Thefe incircled a much greater quantity of the metal, divided into grains and drops of various

rious fizes, by the interpofed charcoal powder.

Having carefully feparated the lead and charcoal from the glafs, I found their weight to be 7200 grains, of which the charcoal made more than half the weight of the quantity employed; but how much more I could not afcertain fatisfactorily, becaufe a little of the lead adhered to that which I feparated mechanically, and fome of the charcoal followed the lead and was wafted in the fufion of it. Another circumftance contributed likewife to prevent my knowing the exact weight of the refiduary charcoal; for it had imbibed, in cooling, fome of the fixable air remaining in the receiver, and perhaps a little atmofpheric air.

As the charcoal expended in this operation was certainly much lefs than half an ounce, = 240 grains, and I had found by other experiments fimilar to that which is next to be related, that 7680 grains of lithrage require only 213. 7 of charcoal

for

for the reduction, I have no doubt that this laſt was the quantity expended.

The quantity of earth and alkali in 213. 7 of charcoal being too ſmall to claim our attention in this place; and the phlogiſtic air of the lithrage, and the inflammable air of the ſuperfluous charcoal, having contributed nothing to the other products; we may ſay the empyreal air of the lithrage, weigh- ing 736 grains, together with 213. 7 grains of expended charcoal, produced 650 grains of fixable air, and a quantity of water great- ly exceeding that which was ſaved : and ſince the weight of the efficient charcoal and of the empyreal air, making 949. 7 grains, exceeds that of the fixable air by 299. 7 grains, this laſt appears to have been the quantity of water formed, though not all condenſed, in this operation.

To form this quantity of water 42. 8 grains of phlogiſton are neceſſary, accord- ing to the admirable experiments of Mr. Cavendiſh; and as there is no reaſon for

ſup-

suppofing that the charcoal contained more
than this quantity, which is ⅟₅ of its weight,
of phlogifton, no part of this laft appears
to have entered the lead, or contributed to
the fixable air, or to have been otherwife
expended than in the formation of water.
By this computation, no more than 171
grains of the expended charcoal, was em-
ployed in the formation of the fixable air;
and as 256. 8 grains of the empyreal air,
were expended in the water, no more than
479. 2 grains contributed to the fixable
air; and in 650 grains of it, the empyreal
air was to the acid matter as 479. 2 to 170.
8 or as 2. 8 to 1.

This proportion differs confiderably from
that which was computed, in regard to the
fixable air from acetous compounds; but
whether the difference is owing to an er-
roneous eftimation of the mere acid in ace-
tous acid, and of the quantity of fixable
air which it can yield by heat alone; or
to a capacity of the principles of fixable

<div align="right">air</div>

air to unite in different proportions, when they meet in different circumſtances, or with a great exceſs of one or the other, I cannot yet determine.

SECTION XIX.

Products in the reduction of lithrage and calx of mercury with the smallest quantity of charcoal.

IN order to avoid the inconveniences arifing from an excefs of charcoal, and to find the greatest quantity of lithrage that can be reduced by a known weight of it, as well as the produce in fixable air and water, I made the following experiment with 120 grains of charcoal, and 7680 grains of lithrage, prepared and mixed in the manner already defcribed.

A fmall retort, well coated, and charged to the helm with the mixture, was placed in an earthen veffel, and furrounded with as much fand as filled the fpace between them, and was fufficient to cover the helm and a part of the neck.

I

The retort thus fecured, was made to ftand high above the bed of the furnace, in order that the fire might act equably around the charge, and fufe the lead into one folid mafs, of which no part fhould be loft, although the glafs fhould be penetrated by it. Thefe meafures were alfo intended to produce a fteadier emiffion of the elaftic fluids than happened in the preceeding experiment.

Rejecting the atmofpheric air of the veffels, I meafured the products of the charge gradually heated, thus.

cub. in.	fixable air.	phlogiftic air	
firft 18	5	13	
next 18	13.2	4.8	{ phlog air with $\frac{1}{10}$ of emp. air.
next 18	15.6	2.4	{ phlog. with $\frac{1}{6}$ of emp. air.
18	17.4	0.6	{ phlog. with $\frac{1}{5}$ empyreal air.
18	17.8	0.2	ditto
18	17.9	0.1	ditto
18	17.91	0.09	{ phlog. with $\frac{1}{4}$ of emp. air.

T   After

After the 32 cubic inch of emitted airs, ten grains of water were saved in the recipient, and after this last measure about 25 grains were saved.

54	53.73	0.27 ditto
90	89.55	0.45 ditto
90	89.55	0.45 ditto

Each of these portions in passing in large columns into the common air through water, shewed watery vapour suspended in them, and bedewed the vessels in which they were cooled.

90	89.55	0.45 ditto
90	89.55	0.45 ditto
90	89.55	0.45 ditto
90	89.55	0.45 ditto
90	89.55	0.45 ditto
90	89.55	0.45 $\left\{\begin{array}{l}\text{phlog. with } \frac{1}{3} \\ \text{empyreal air.}\end{array}\right.$
36	35.8	0.2 $\left\{\begin{array}{l}\text{equal parts of} \\ \text{these.}\end{array}\right.$

In

In this laſt is included the air left in the veſſels whilſt they were hot. Towards the end, the emiſſion gradually decreaſed in velocity, and it ceaſed at the laſt cubic inch; although the heat had been more than ſuf-ficient for the reduction of litharge, for 15 minutes. The fire was now withdrawn.

The ſum of the cubic inches
Of hot fixable air was,	910.74
Of temperate phlogiſtic air	23.09
Of temperate empyreal air	2.17

The water ſaved amounted to 49 grains, although a great quantity was certainly carried off by the fixable air, notwithſtand-ing every endeavour to moderate and equa-lize the heat.

The fixable air, when it had contracted by cooling to the mean temperature, was eſtimated at 384 grains, at the rate of .57 gr. to a cubic inch; but I ſtrongly ſuf-pected that the ſpecific gravity of this fixable air was not ſo great, and conſe-

quently

quently that the abfolute weight was lefs than 384. The phlogiftic air weighed 8.704 grains, and as fome part of it proceeded from the unreduced litharge, which preyed on the veffel, and yielded fome of its empyreal air, the phlogiftic air appertaining to the revived litharge may be ftated at 8 grains. The empyreal air weighed 0.911 grains.

In the retort I found a cake of litharge, a quarter of an inch thick, vitrified into an opaque yellow flag with part of the glafs of the retort, and the erofion extended in fome parts through the coating as far as the fand ; but yet the toughnefs of the flag prevented all tranfpiration in this quarter, for the refiftance to the paffage of the elaftic fluids into the meafures, was only an half inch column of water.

Under the litharge I found a mafs of lead, and a few large grains which had bedded themfelves in the glafs, all together weighing 3888 grains. There was not the fmalleft veftige of charcoal ; and as the

earthy

earthy and alkaline parts of it, were incon-
fiderable, and were vitrified in the mafs
already mentioned, they did not retain any
aerial matter of charcoal; for by repeated
experiments I have found that fuch vitre-
ous mafles, and even the fineft flint glafs,
retain nearly the whole of the empyreal air
of litharge, but cannot, in perfect fufion to
fluidity, hold any confiderable quantity of
fixable air.

Not a particle of inflammable air was expel-
led in this experiment, becaufe the litharge,
in the degree of heat neceffary for expel-
ling inflammable air from charcoal, fur-
nifhed empyreal air enough to unite with
the inflammable air, and contained a re-
dundancy of air beyond what the inflam-
mable matter of the charcoal required. A
little of this furperfluous air was expelled
by the great heat to which the litharge was
expofed and in the act of vitrification,
for when litharge forms glafs with clay or
fand, it parts with a little of its emp. air.

As

As the lead weighing 3888 grains, yielded 424. 513 of air, of which eight may be accounted phlogiftic, the empyreal air of the reduced lithrage, amounted at leaft to 416. 513. gr. and this quantity with 120 grains of charcoal, making 536. 513 gr. afforded fcarcely 384 grains of fixable air, and a quantity of water, which was not lefs than 152. 513 grains, but might have been more. Towards the formation of this water, from 22 to 24 grains of phlogifton were neceffary, which laft is a fifth part of the weight of the charcoal, by this approximation we account for as much phlogifton as the charcoal can well be fuppofed to contain. As the water engaged at leaft 130 grains of empyreal air, if not more ; the fixable air engaged about 287 of empyreal air, and derived about 96 or 97. 5 of acid matter from the charcoal. Thus the empyreal air feemed to be to the acid matter in this fixable air, nearly as 3 to 1 ; and if the weight of the fixable air had been taken at lefs than 57 grains in a cubic inch, or its abfolute weight had not been overrated by affuming a greater fpecific gravity than it really
<div align="right">poffeffed</div>

poffeffed, the proportion of the empyreal
air to the other matter of *this* fixable air
would be perhaps accurately 3 to 1. Regard-
ing all this only as an approximation to the
truth, and trufting that the errors cannot
be fo great as the difference between 3 and
2, I am of opinion that fixable air formed
in thefe circumftances, contains more em-
pyreal air than is in the ordinary fort,
and that whilft fome fpecimens of fixable
air have but $\frac{2}{3}$ of their weight of empyreal
air, others have $\frac{3}{4}$ and differ in fpecific gra-
vity; the circumftances which afford this
latter proportion being, ftrong heat, and
redundancy of empyreal air.

As empyreal air is a common principle of
fixable air and of water; and as it actually
makes water with the phlogifton of char-
coal, at the fame moment that the like
empyreal air engages other matter of char-
coal, and makes fixable air with it, there is
no ground for the opinion that phlogifton
is a neceffary principle of fixable air; but all
our experiments confpire to fhew, that it
confifts of the gravitating matter of empy-

real

real air, combined with that acid princi-
ple which is common to acetous acid, oils,
coal, vegetables, denfe inflammable air, &c.

But as every acid may fubfift partially
phlogifticated and imperfectly impregnated
with empyreal air, fo may fixable air; and
it is to be expected that future experiments
will fhew confiderable varieties in fixable
air, arifing from thefe caufes, and difcover-
able by the fpecific gravity, the menftrual
powers, and the different bulks imbibed
by water.

By the quantity of elaftic fluids and wa-
ter, and the total expenditure of the char-
coal in the formation of them, it is now
pretty certain that litharge lofes its aerial
matter, but receives nothing in the reduc-
tion, and confequently lofes none of its
phlogifton in calcination : It is therefore
highly probable that all calcinations and
reductions of metals are effected in the fame
way.

In

In the reduction of mercurius calcinatus by charcoal, I have found that water is formed as well as in the reduction of litharge, befides the fixable air which Mr. Lavoifier had noticed. But this fixable air did not appear to contain more than $\frac{2}{3}$ of its weight of empyreal air: and in this inftance it is certain that no part of the phlogifton of the charcoal is neceffary towards the metallization, becaufe the empyreal air can be expelled, and the mercury may be revived, without charcoal, and by heat alone.

It is impoffible for a man who muft employ the greater part of his time in the duties of a profeffion which allows no vacation, to fuperintend fuch experiments as thofe on which the foregoing eftimations have been founded, from the commencement to the termination; and being thus circumftanced, I think it neceffary to obferve, that fome part of every one of thefe experiments and menfurations, was committed to the care and fidelity of my operator. If any unintentional errors on his part fhould happen to confpire to the encreafe of mine,

4   my

my eftimations may be very incorrect in regard to the proportions; but I have no reafon to doubt that the notions of metallic reduction, of the principles of fixable air and denfe inflammable air, and of all that does not depend on accurate proportion, will abide the teft of future experience.

S E C-

SECTION XX.

*Phenomena of the combuſtion of denſe inflam-
mable air, and of ſubſtances containing the
acetous and phlogiſtic principles; and men-
ſuration of the products.*

IN order to fire large charges of inflam-
mable air without waſte or danger, I
provided glaſs jars that were ſtrong enough
to bear an exploſion equal to that of a piſtol
charge of gunpowder. The cylindrical ca-
vity of each was ten inches in length and
one in diameter; and at the diſtance of
$\frac{2}{10}$ of an inch from the bottom, two
holes were drilled at right angles with the
axis of the cylinder. Into each of theſe
holes a piece of braſs wire, $\frac{1}{10}$ of an inch in di-
ameter, rounded at one end and ringed at
the other, was cemented, ſo that the diſ-
tance between the rounded ends within the
veſſel did not exceed $\frac{1}{5}$ of an inch, and that
the

the ring of each wire did not project above $\frac{3}{10}$ of an inch, for longer pieces were found to be inconvenient.

By thefe means I could make the electrical fpark taken between the wires, to be great or fmall, according to the fize or charge of a Leyden jar, employed for this purpofe. That part of each exploding jar, which was to be occupied by an elaftic fluid previous to the ignition by the electric fpark, was graduated, in order to fhew any errors in the menfuration, or wafte in the introduction of them ; and alfo to fhew the quantity of elaftic fluid remaining after an explofion.

By repeated trials I found that a cubic inch of the due mixture of inflammable and empyreal air, was the greateft quantity that could be fired at once, in an exploding jar of this kind, without wafte of the quickfilver in which it ftood inverted, and which was impreffed and agitated violently at each explofion ; or without manifeft lofs of the inflamed and dilated airs : And I

was

was convinced that the brafs wires had no
fenfible effect in any of the experiments
that I am now to mention.

To hold the exploding jar in the re-
quired pofition, a brafs collar was faftened
to it by fcrewing the ends of the collar to-
gether, and a piece of brafs projecting from
the collar, and fliding into a heavy frame
of iron, connected the whole, fo that the
exploding jar might recoil an inch or a little
more; but not without moving the whole
frame, which refifted with a force of 14
pounds.

After fome trials in this inftrument, I
obferved that the inflammable air which
was firft expelled from an acetous falt by
the weaker heat, required almoft double its
bulk of empyreal air for its combuftion, by
reafon of the ethereal vapour mixed with
it, or of its extraordinary denfity. But
that the inflammable air expelled laft by
the ftronger heat, and duly feparated from
the fixable air, required much lefs empy-
real air, and was of a rarer kind, a cubic
inch

inch of it weighing fcarcely $\frac{2}{10}$ of a grain.
Even this inflammable air fuffered a confi-
derable diminution of its bulk by repeated
agitation with lime liquor, and by long ex-
pofure to water.

The difpofition of the inflammable air
from acetous falts, to vary thus by time,
by the unavoidable wafhing, and the expo-
fure to water, as well as by the degree of
heat in which it is procured, is 'apt to per-
plex and miflead the experimenter; for a
flight error in regard to the fpecific gravity of
the inflammable air, induces great errors in
his eftimation of the products after com-
buftion, as may be gathered from the fol-
lowing experiment.

In the exploding jar I fired a mixture
confifting of 5. 5 cub. inches of inflam-
mable air of the pureft kind from acetous
calcareous falt and which had been well
wafhed in lime liquor, and of 7. 5 cub.
inches of empyreal air, in feparate charges
of a cubic inch each, and transferred the
refiduary air of each explofion into a refer-
voir,

voir, through mercury. This air meaſured
five cubic inches and was fixable air, which
lime liquor readily imbibed, leaving a ſmall
bubble of phlogiſtic air, not worth notice
in regard to the weight.

In each explofion the concuſſion of the
apparatus was violent, and the vivid red
flame ſhewed that the charge had at this
inſtant expanded to eight times its former
bulk, and depreſſed the mercury ſo far, al-
though in the next inſtant, and quicker
than the eye could trace it, the reſidu-
ary air meaſured only half the charge:
ſoon after it contracted further by cooling.

The internal ſurface of the jar, as far as
the mercury had been depreſſed, was moiſ-
tened; and this with the water which en-
circled the mercurial column at its ſurface
and contiguous to the jar, ſhewed clearly
that the water formed was a conſiderable
part of the exploded airs. Until it appears
that fire gravitates fenfibly in the quantity
here emitted, we muſt confider the quan-
tity of water thus formed, to be equal to
that

that by which the weight of the mixed airs
exceed that of the fixable air.

The weight of the empyreal air
    at 42. grains in the cubic
    inch was   -   -   3. 15 gr.
That of the inflammable, at . 2 gr.
    in the cubic inch was   -   1. 1
And the weight of both   4. 25
The fixable air, at .57 gr. to the
    cubic inch, weighed   -   2. 85
Confequently the water weighed 1. 4
Mr. Cavendifh's ingenious and
    accurate experiments fhew that
    one feventh of water is phlo-
    gifton, and the remainder
    empyreal air.
In the formation of 1. 4 gr. of
    water, the quantity of phlo-
    gifton expended was   -   .2
And the empyreal air expended
    was   -   -   1. 2
The part of the empyreal air
    which entered in the com-
    pofition of the fixable air, thus
    appeared to be   -   1. 95
                       And

And the quantity of matter
   furnifhed by the inflammable
   air towards the finable air
   was about   -   0, 9 gr.

By other experiments and the fame kind
of eftimation, the empyreal air appeared to
conftitute more than two thirds of the fix-
able air, and in fome it feemed to be accu-
rately $\frac{2}{3}$; but after all I continued to fuf-
pect that the proportions of the principles
are not the fame in every fpecimen of the
elaftic fluid which we confider as fixable
air. When the denfe inflammable air firft
expelled from charcoal was ufed, the refult
was nearly the fame. And from the whole
I conclude, that when as much inflammable
air of this kind is employed, as can be con-
verted, in the explofion, by the empyreal
air, the fixable air confifts of one part by
weight of the acid matter of acetous acid
or charcoal, and nearly or accurately two
parts of empyreal air; and almoft $\frac{1}{7}$ of this
kind of inflammable air is **phlogifton**, and
the remainder mere acid bafis of fixable air,
and of acetous acid, charcoal, oils, fpirits,
U   and

and of all fubftances that yield acetous acid
or denfe inflammable air abundantly.

Nothing appears to warrant the current
opinion that fixable air contains phlogifton ;
but on the contrary the water fhews that
the attractive forces confpire to the union
of the phlogifton with empyreal air, to form
water, even in the prefence of the princi-
ples of fixed air ; and the quantity of phlo-
gifton which we trace in the water, being
$\frac{1}{5}$ of the weight of the inflammable air, is
as great as can by any experiment hitherto
made, be fhewn to exift in inflammable air
of this fpecific gravity.

When I ufed the heavier inflammable air
carrying ethereal vapour, it required more
empyreal air to burn the whole of it, fo that
no inflammable refidue fhould appear after
the fixable air had been abforbed by lime-
liquor ; and then the bulk of fixable air
was greater in relation to that of the in-
flammable.

When no more than the neceffary quan-
tity of empyreal air was ufed, the quan-
tity

tity of phlogiftic air that appeared after the
explofion, did not differ fenfibly from that
which appeared, by other experiments, to
have been introduced in the empyreal air
or the inflammable air: It was greateft
when I ufed inflammable air that had iffued
at the commencement of a diftillation, or
that had been long expofed to water; or
when I ufed the impure air expelled from
nitre; and it was leaft when the pureft airs
were ufed. Therefore the invariable and
proper products in the combuftion of denfe
inflammable air with empyreal air, are
fixable air, water and fire, and nothing elfe.

It is well known that charcoal continues
to yield denfe inflammable air, as long as
it is urged with intenfe heat; and if the
experiment were purfued to the utmoft ex-
tent, the whole of it, except the earth,
might be converted into this kind of air.
But even from charcoal, the air firft expel-
led by the weaker heat, is heavier than that
which is afterwards procured by intenfe
heat. And as the heavieft inflammable air
from charcoal or acetous compounds, yields

the

the greateſt quantity of fixable air in com-
buſtion; whilſt the light inflammable air
of metallic ſolutions yields none, as Mr.
Cavendiſh truly maintains; and as it is
certain that phlogiſton is a common prin-
ciple of both, the greater ſpecific gravity
of the former is to be imputed to the acid
mattter.

It ſeems therefore that the proportions,
in which the acid and phlogiſtic matter are
combined, in different ſpecimens of inflam-
mable air expelled from vegetable ſubſtan-
ces, do vary conſiderably, and that the den-
ſer air, containing the greater quantity of
acid matter, is more eaſily expelled than the
rarer, which not only holds phlogiſton in
greater proportion, but is perhaps more
fully ſaturated with the matter of fire, in
conſequence of the predominance of phlo-
giſton, and the intenſer heat in which it is
always formed.

To theſe cauſes I would impute the great
ſpecific gravity of the inflammable air of
oils, ſpirits, Ether, reſinous ſubſtances, and

of that which mineral fuel emits at firſt in diſtillation; and the ſingular levity of the inflammable air expelled from coal by intenſe heat.

In the combuſtion of divers ſpecimens of inflammable air, with the ſole view of ſatisfying myſelf that they all could yield fixable air and water, I occaſionally uſed air expelled from nitre by heating it in a coated glaſs retort. Finding that the firſt gallon or the ſecond was not ſo pure as the four ſubſequent gallons emitted from a pound of the pure ſalt, and that in the ſubſequent meaſures the impurity encreaſed, I reſerved the beſt for uſe; but even in this the phlo-giſtic air made $\frac{1}{14}$ of the bulk; for this quantity appeared by Dr. Prieſtly's teſt of nitrous air, and by expoſing the empyreal air to the ſolution of calcareous liver of ſulphur.

In the uſe of this air, or of inflammable air equally impure, I found that the phlo-giſtic air introduced in either, ſuffered little or no diminution in conſequence of the ex-ploſion,

plofion, when the quantity of inflammable air was great enough to employ the whole of the empyreal in the formation of fixable air and water ; but when the empyreal air exceeded this proportion, a part of the phlo- giftic air difappeared : this was found by expofing the products of the explofion, firft to lime liquor, in order to feparate the fix- able air, and then to the folution of calca- reous liver of fulphur, which after imbi- bing the empyreal air, fhewed the quantity of the phlogiftic.

When I had ufed the proportions in which of the greateft diminution of the phlogiftic air had taken place ; the water formed at the fame time acquired an acid impregnation, acted on the mercury, and became turbid with it. The moft fa- vourable circumftances to the production of this phenomenon were, the redun- dancy of empyreal air, and the repeated expofure of the whole refidue of an ex- plofion, to the fhock and flame of fubfe- quent charges.

From thefe phenomena I concluded two years ago, that the gravitating matter of phlogiftic air is contained in nitrous acid, and that phlogiftic air in the circumftances now defcribed, contributes to the formation of an acid ftrongly refembling the nitrous. This did not amount to a clear knowledge of the fubject.

But Mr. Cavendifh, by a happy train of reafoning from experiments devifed by himfelf, and knowing nothing of thofe which I have now related, has clearly fhewn in the laft volume of the Philofophical Tranfactions, that empyreal and phlogiftic air expofed to electric fparks, form nitrous acid; and it is no longer to be doubted that the phlogiftic air was thus expended in my experiments, which now ferve only to fuggeft an eafy and expeditious method of making nitrous acid from empyreal and phlogiftic air, and to fhew that flame or due ignition ferves as well as the electric fpark for this purpofe.

But as there was no appearance of nitrous acid whilft the inflammable air predomi-

nated

nated in the charge, we may infer, that em-
pyreal air is attracted more forcibly by the
acid matter of denfe inflammable air, or
of the bodies which yield it, than by that
of phlogiftic air; and that it is by virtue
of this fuperior affinity, that all vegetable
and other fubftances, abounding in our
acid matter, and deflagrated with nitrous
falt, engage the empyreal air of the ni-
trous acid in the formation of fixable air
and water, and leave the refiduary matter
of the nitrous acid in the form of nitrous
air or phlogiftic air.

Tin imbibes more air in calcination than
any other metal, unlefs we except regulus
of manganefe or iron, which I have not tried.
Sixteen ounces of tin encreafe in weight to
20 ounces by calcination: But in calcining
filings of tin with empyreal air I could not
difcover any confiderable quantity of fix-
able air, and iron produced but a little.
As we do not find fixable air in the
combuftions of zinc, or phofphorus of
Runkel, or light inflammable air, altho'
thefe are vivid in the higheft degree, our
<div align="right">acid</div>

acid matter is not a neceſſary agent in com-
buſtion, but rather ſeems to moderate it;
for the bodies which yield the greateſt
quantity of fixable air in combuſtion, af-
ford the weakeſt heat and illumination;
and this correſponds with the capacity of
fixable air to retain a great part of the mat-
ter of fire which belonged to its principles,
and the inability of water to fix any conſi-
derable quantity of the matter of fire be-
longing to empyreal air and phlogiſton ſe-
verally. Hence it happens that coak makes
a much ſtronger fire than charcoal, altho'
the former contains ten times more cineri-
tious matter than the latter; for coak yields
lighter inflammable air, and affords leſs fix-
able air, and conſequently contains leſs acid
relatively to its phlogiſton, than charcoal.

In the combuſtion of charcoal with em-
pyreal air, the expenditure of the latter, in
fixable air and water, was always found to
be more than thrice the weight of the char-
coal. I could now eaſily aſcertain the pro-
portions of theſe, and even the quantity
of

of the acid and phlogiſtic matter in this and
other bodies; but as my preſent purpoſes
are anſwered by approximation, I think it
unneceſſary to detain the reader any longer
on this ſubject.

SECTION XXI.

Primary notions of the matter of Fire.

IN order to fuggeft a more extenfive ufe
of the foregoing obfervations, and to fa-
cilitate the explanation of certain pheno-
mena which are yet to be confidered, I am
now to propofe a few neceffary notions of
the matter of fire.

1. *The kind of matter which impreffes us
with a fenfe of heat, and which is capable
of expanding and pervading all known bo-
dies, is fubject to laws of attraction, which
fixes and difguifes a certain quantity of it
in divers fubftances; and this matter pro-
duces the effects which we call heat, and acts
as fire, only when it is extricated from other
kinds of matter.*

This notion needs no illuftration or fup-
port; for the phenomena which confpire

to imprefs it, are very numerous; and Black, Bergman, Cavendifh, Crawford, Prieftley, Kirvan, Lavoifier, and other diftinguifhed philofophers, have adopted it.

2. *The homogeneal parts of the matter of fire repel each other.*

This repellent property is apparent in all the procefles in which the matter of fire is extricated from the grofler and gravitating parts of bodies. The chief of thefe procefles are the mixtures producing heat, the abforptions of divers cold elaftic fluids caufing heat, vitriolizations, incalafcence of pyrophori, refpiration, putrefaction, fermentation, and combuftion. In all thefe, the matter of fire, fo foon as it is liberated, is found by its peculiar effects, and the menfurable decreafe of heat at encreafed diftances from the fource of emiffion, to move excentrically from that fource, and to decreafe in denfity. But as this happens, whether the extrication of it be attended with illumination or not, it indicates nothing that is confiftent with the

the tenour of nature, or that may be fug-
gefted by analogy, except that the parts of
the matter of fire repel each other, al-
though they certainly are attracted by other
kinds of matter. This repellent property
is equally apparent in every inftance of the
formation of elaftic fluids from aggregate
bodies; and efpecially when this is done
by mere ignition. But as thefe inftances
afford another inference of equal ufe, I fhall
fubjoin them to the following notion.

3. *The matter of fire, by virtue of the re-*
pulfion fubfifting between its homogeneal parts,
and of their attractions to the parts of other
matter, is the caufe of the elafticity of aeriform
fluids.

This notion is neceffary to the folution of
the phenomena, and is fupported by direct
evidence, of which the following part will
be fufficient.

Oils, Refins, vegetable acids, charcoal,
and divers other bodies, are almoft totally
convertible into fixable air, and inflamma-
ble

ble air by fire. Nitrous acid may be de-
compofed and converted, in part, into empy-
real air, in the remainder into phlogiftic or
nitrous air, by the agency of fire. The
whole fubftance of folid nitrous ammoniac
is convertible into fluids permanently elaf-
tic, by the mere action of fire. From the
folid aggregation in manganefe and other
metallic calces and in divers falts, the grofs
matter of empyreal air may be propelled, to
form an elaftic fluid, by fire; fo may that
of denfe inflammable air from coak and di-
vers hard bodies; that of fixable air from
ftony concretes; that of alkaline air from
ivory, Pruffian blue, and microcofmic falt;
that of vitriolic, or of marine, or of hepa-
cit air, from divers folid, faline, or fulphu-
reous compounds. All this is done by fire;
and being beft effected in veffels that are
impervious to every other known matter,
amounts to a fatisfactory proof that the
matter of fire is the only acceffary and agent
in the converfion of folid bodies into elaftic
fluids, and in the maintenance of their
elafticity.

The

The electric matter is not to be mentioned in objection, until it is proved that it does not itfelf confift of the matter of fire, in a certain modification of it, depending on the repulfive property, and the relations to grofs matter, which we are now defcribing.

Seeing this extenfive agency of the fiery matter; that we can not only trace it into the fubjects which thus become permanently elaftic, but that it gives a temporary elafticity to vapours and fublimates; feeing that thefe refume their aggregation as faft as it efcapes from them; that its union in the fluids, to which it gives permanent elafticity, may be further proved by the extrication of it from every one of them; and that, in thefe liberations of it which are daily experienced, in the abforptions of elaftic fluids, in combinations, and in combuftions of them, the emiffion is fo copious as to remove all doubt of their having held it in great quantity, united with their refpective feparated parts, and reftrained during that union from acting like liberated

fire;

fire; obferving alfo that as faft as the fire is liberated or excluded, the diftant groffer parts of elaftic fluids rufh together or into other bodies; as when empyreal and nitrous air make nitrous acid, or empyreal and light inflammable air make water which cools to folid ice, or marine and alkaline air make fal ammoniac; or as when acid or alkaline airs rufh into water, or empyreal air into phofphorus; we cannot now hefitate in admitting that the groffer parts of elaftic fluids, as well as thofe of vapour, are made to recede from each other contrary to their inherent and inceffant attractive powers, by virtue of their refpective charges of the repellent matter of fire, and confequently by the repulfion of the parts of fire to each other.

4. *The charges of repellent matter, by which attractive and gravitating particles form elaftic fluids, are diftinct atmofpheres of fiery matter, in which the denfities are reciprocally as the diftances from the central particles, in a duplicate or higher ratio.*

This

This is an evident confequence of the
former notions, and the prevalence of the
repulfive over the attractive forces ; and the
terreftrial atmofphere, in which the denfity
is inverfely as the fquares of the diftances
from the earth, fhews that it is the natural
and neceffary effect of fuch forces, to form
the charges of fiery matter which the par-
ticles engage, into the defcribed atmof-
pheres. The further evidence of the truth
of this notion arifes from phenomena,
which I am prefently to confider and ex-
plain, and which are not inexplicable by
any other condition or agency of the matter
of fire, that has been hitherto fuggefted.

5. *The repulfion of the homogeneal parts
of the mattter of fire, limits the quantity
that can be engaged by bodies, and tends
to diffufe the remainder equably in fpace.*

This notion needs no illuftration.

6. *The matter of fire limits the quan-
titics, in which aeriform fluids, and bo-*

dies

dies containing it, can combine chemi-cally.

In the converfion of folid bodies into elaftic fluids, we perceive the repulfive forces of the matter of fire refifting and overpowering the reciprocal attractions of the groffer parts ; and in mixtures of empyreal and inflammable air, and in divers other mixed airs, we fee this matter refifting the attractions which tend ftrongly to the chemical combination of the heterogeneal gravitating particles.

In fuch inftances it is manifeft that the fum of the repulfive forces, exceeds that of the attractive.

When aeriform fluids condenfe each other, or are concentrated and aggregated by bodies, it is equally evident that the attractive forces, although refifted by the repulfive, are prevalent.

Thefe, and divers other phenomena fhew, that the natural power, whether attractive

or

or repulfive, of each part of matter, is li-
mited; and therefore the fum of the pow-
ers which any body can exert in regard to
another, is by a law of nature as the num-
ber of its active parts, or in other words,
as its quantity of matter.

In confequence of this law, the fum of
the repulfive forces, which refift the ap-
proximation of the gravitating parts of an
elaftic fluid, and their union with thofe
of a body which alfo holds fome of the
matter of fire, is as the quantity of that
fluid; and no more than a determinate
portion of it can be aggregated and com-
bined in the body whofe quantity of mat-
ter and attractive powers are limited.

By the fame law it is determined that elaftic
fluids fhall unite with each other in limi-
ted proportions only, to form denfer fluids
or folid bodies, and that the fuperfluous
quantities fhall remain elaftic and unal-
tered.

As

As the matter of fire is manifeſtly the agent which reſiſts the coaleſcence and union of attractive particles in theſe caſes; and as the ſame matter demonſtrably exiſts in all bodies that unite only in limited proportions, we muſt aſcribe to this only competent and manifeſt agent, all thoſe limitations which we experience, in regard to the proportions in which bodies can be chemically united, and which we briefly expreſs by the word *ſaturation.*

SECTION XXII.

Applications of the foregoing notions in the explanation of divers phenomena.

AS the limits of this Effay do not permit me to make extenfive applications of the foregoing notions, I fhall endeavour, in the expreffion of a few, in this and the following fection, to fuggeft every thing that feems neceffary towards explaining the moft intricate phenomena of the matter of fire.

In regard to the apyrous bodies, fuch as the pure earthy fubftances, I would infer from thefe notions that they chiefly confift of parts which do not attract the matter of fire with forces fufficient to caufe a difunion of them, and an interpofition of this matter in fuch quantity as to induce foftnefs or fluidity.

Concerning fufible bodies which concrete in cooling, I would in the next place infer,

X 3

that

that they confift chiefly of parts which at-
tract the matter of fire with forces fome-
what greater than thofe laft mentioned,
and fufficient to effect the folution of them
in the fiery fluid, but not for the perma-
nent retention of it : That bodies of this
clafs exclude the folvent by virtue of the
prevalent attractions which tend to reunite
their grofs parts ; but that they receive and
tranfmit the matter which caufes heat, more
freely, and they retain it longer, than the
former can in fimilar circumftances, by
reafon of the ftronger attractions.

The bodies which, like oils or water,
form elaftic vapour, when duly charged
with the matter of fire, confift chiefly of
parts which attract it with forces ftill
greater, and fufficient to compel atmof-
pheres around the diftant molecules ; but
yet not fufficient to retain thefe atmof-
pheres after the influx of fire ceafes, and
in oppofition to the mutual attractions of
their central molecules, and the tendency
of the fiery matter to diffufe itfelf equa-
bly in the neighbouring fpaces. As the
ther-

thermometer shews no more than the re-
lative quantities of the free matter of fire
in bodies, these lately mentioned require
a greater quantity of the fiery matter than
the former, before they exhibit an equal
temperature by the thermometer, for the
reason already mentioned.

It is also by virtue of this superior at-
traction to the fiery matter, that ice, resin,
fats, and other vapourable bodies, become
fluid by moderate incalescence, but not be-
fore they have received a great quantity of
fire ; and that they respectively evaporate
with less ignition or incalescence, in vessels
which avert the pressure of the aerial at-
mosphere, than where that, or any equiva-
lent compression, conspires with their ag-
gregate attractions, to resist the influx of
fire and the disjunction of their parts.—
Thus water, or spirit, moderately heated,
and placed in the receiver of an air-pump,
boils when a part of the air which com-
presses it is drawn out, and ceases as often
as the pressure is restored.

Still

Still ſtronger attractions of the matter of fire, comparatively with the forces which tend to the excluſion of it, are ſeen in ethereal oils and Ethers : For their vapours cannot be condenſed without the aid of compreſſion ; and when they are thus condenſed and aggregated, their molecules, by attracting fiery matter and compelling it into atmoſpheres, with forces ſuperior to thoſe with which they attract each other, are made to recede, and form aeriform fluids, in the loweſt temperatures, ſo ſoon as the preſſure of the almoſphere is averted.

That the expanſion of ſuch ethereal fluids into the aerial form, in the exhauſted receiver of an air-pump, is owing to the tendency of their molecules to attract the matter of fire and to form atmoſpheres of it around them ſeverally, and that it is not effected by any other agency, is apparent from the concomitant phenomenon of *cold* : For as faſt as they aſſume the aerial form, they engage and fix the free fiery matter which belonged to the ſpaces into which
they

they expand; and this privation or defici-
ency of difengaged fiery matter, is what
we call cold.

The bodies which by ignition may be
partially or totally converted, even under
the atmofpheric preffure, into fluids perma-
nently elaftic, fhew the kinds of matter
by which that of fire is attracted in the fu-
preme degree.

For the elafticity which fubfifts under
immenfe preffure, argues a ftronger attrac-
tion of the particles to their refpective re-
pellent atmofpheres, than that which we
laft noticed; but that this ftronger attrac-
tion compels denfer and deeper atmof-
pheres, may not only be argued a priori, but
is experimentally demonftrable by the bulk,
which in elaftic fluids is the meafure of the
atmofpheres, compared with the gravity,
which is the meafure of the grofs particles;
and it is alfo apparent in the extraordinary
quantity of the fiery matter that efcapes in
the inftant of the aggregation of thefe
elaftic fluids, or rather of their particles,

to

to form confiftent bodies; As when empyreal air is rapidly imbibed by phofphorus, Pyrophorus, Hepar fulphuris, or iron filings and fulphur; when alkaline air, and divers acid airs, are abforbed by water, or when they condenfe each other; or when the rare inflammable air and empyreal air make water, and exclude their matter of fire.

From all this it may be inferred, that in any future table of the affinities of the matter of fire, *pure phlogifton* ought to rank above every other kind of matter; inftead of being omitted, as it is in Bergman's tables, or fuppofed to have repugnance or apathy to the matter of fire, as Dr. Crawford formerly conjectured. But when this precedence is given to phlogifton, by reafon of the extreme levity of the purer inflammable air of metallic folutions, and of the quantity of fiery matter which it emits in the inftant of its union with empyreal air, the gravitating matter of this laft air muft not be placed beneath any other that is now known; becaufe no air that is free

from

from phlogifton, is lighter fpecifically than
empyreal air; or emits more fire in the in-
ftant of aggregation.

I confider the fpecific gravity as a fafe
guide in our inveftigations of thefe affini-
ties and of their order, in regard only to
the elaftic fluids which feem to confift of no
more than one kind of gravitating matter
engaged in the repellent atmofperes : And
of fixable air, denfe inflammable air, acid
airs, the phlogiftic alkaline air, and others,
I would obferve, that the atmofperes in-
clude molecules inftead of folitary ultimate
parts; for without this chemical union
of heterogeneal parts, and the formation
of molecules, an elaftic fluid of the kind
that I now fpeak of, could not differ, as it
does, from either kind of matter of which
it is compofed.

From this confideration of the attractive
forces which tend to form molecules, and
of the atmofpheres which, in compound
elaftic fluids, encompafs the molecules, but
not the ultimate parts feverally, we derive
an

an eafy explanation of the phenomenon fo often noticed in the preceding pages; I mean the converfion of a fubftance, not into one, but into two or three different elaftic fluids, by mere ignition.

When elaftic fluids are formed in folutions and other proceffes, in which the fubjects are not ignited, it is to be obferved that the gravitating parts of the emitted elaftic fluid, were diftant from each other, by reafon of the interpofed matter, at the inftant of their extrication, and that at this diftance there is a great dimunition of the powers which reftrain them in their tendency to engage all the matter of fire that the menftruum or folvent could extricate during their union. Thus it happens, as Dr. Black originally fuggefted, and as Bergman has obferved in his excellent Differtation on Elective Attractions, that cauftic alkali, in the union with an acid, excites great heat, that is to fay, in their union they exclude a part of the matter of fire which they feverally held in a fixed ftate; but mild alkali, in uniting with an acid

acid, gives little or no heat, and for this reason; that the gravitating parts of the fixable air, engage all the liberated matter of fire in forming atmospheres around its molecules. This exposition is applicable to every other elastic fluid that is extricated in solutions or combinations attended with little or no incalescence.

Since the particles which attract the matter of fire, exclude a part of their respective charges in the instant of their close approximation or contact, there is no difficulty in accounting for the cold produced in solutions, expansions, and evaporations; in every one of which, the particles which resume the matter of fire, and in fixing it produce the cold, are previously removed to some distance from each other, either by the interposition of the parts of a menstruum, as when ice is dissolved by nitrous acid, or by the prevalent powers of their proper fixed fire, of which we have an instance in Ether placed in the exhausted receiver of an air-pump.

As

As the mere acetous acid confifts of the gravitating parts of empyreal air, of phlogifton, and the acid principle of vegetables; and by the acceffion of the matter of fire only, makes two different elaftic fluids, namely fixable air, and denfe inflammable air; it follows from thefe notions, that the gravitating parts of thefe two airs would make acetous acid again, with water, if the matter of fire could be withdrawn from them ; and I venture to prognofticate that this, or fomething equivalent, will be done by the firft ingenious experimenter that attempts it, either by the means of a body which may abforb the gravitating matter of both, and exclude their atmofpheres, · or by breaking the atmofpheres in the manner which I am to defcribe in the next fection.

There is undoubtedly a natural limitation, as we formerly obferved, of the forces with which the grofs parts of divers elaftic fluids compel, and are compelled by their refpective atmofpheres ; but ftill thefe forces are fo great, that we cannot form adequate ideas of them, without reflect

ing

ing on the refiftance which they give, even in fmall quantities of the elaftic fluids, to any preffure which tends to condenfe them, and caufe an approximation of their parts; or without adverting to the operations which fhew the ability of thefe forces to maintain the elafticity of divers aeriform fluids, in oppofition to the greateft mechanical powers hitherto employed to fubdue them. The air-gun, and other inftruments exhibit thefe forces in atmofpheric air, and chemical operations and explofive compofitions too often fhew them in the other elaftic fluids.

Although the force of chemical attraction reaches not far from the particles, with any fenfible effect, we are not thence to conclude that the attractive virtue ceafes at any diftance. But from all the known phenomena we may infer, that the attractive forces, tending to the approximation and cohefion of grofs particles, decreafe in a duplicate, or fome higher ratio of the diftances, reciprocally ; that the natural refiftance to the interpofition of the fiery matter

ter

ter, is leſſened at the ſmalleſt, and totally overpowered at ſmall diſtances which no eye can meaſure ; and finally, that *where the ſenſible effect of attraction ceaſes, there repulſion ſucceeds.*

S E C.

SECTION XXIII.

*Interpretations of the most important pheno-
mena of combustion, according to the fore-
going notions.*

AS the atmospheres by which the gross
parts of an elastic fluid are made to
recede from each other, contrary to their
reciprocal attractions, extend into the mi-
nute spaces between them, with decreasing
density; and as the powers which form
these appropriated charges, compell the se-
veral gross parts to the centers of their ref-
pective atmospheres, and regulate the po-
fition of these parts relatively to each other,
as well as their distances; the aerial form
is maintained, not by the mere interposition
of the matter of fire, but by the interven-
tion of it in the described state of density
near the gross particles and extreme rarity
at the coincidence or contiguity of the at-
mospheres.

The

The nature of the fubject admits no in-
ference repugnant to this ; for in a medium
of uniform denfity, the grofs particles
would be impelled or drawn by equal and
contrary powers of the medium, and meet-
ing no refiftance in it, to the attractive
powers which tend to unite them, they
would form an aggregate excluding every
part of the medium, except thofe that might
be abfolutely coherent with the grofs par-
ticles and chemically combined.

Therefore, to deftroy the elafticity, and
to effect the aggregation and union of the
grofs parts of an aeriform fluid, or of any
mixture of different airs, nothing more is
neceffary than to break or blend the atmof-
pheres into a medium of equal denfity in
the fpaces between the particles ; and al-
though this cannot be done by mechanical
compreffion, it is eafily effected by reple-
nifhing the minute fpaces, in which the at-
mofpheres extend, with a denfer fiery fluid.

As the fmalleft fpark affords that denfer
fluid, in quantity fufficient to replenifh

many of thefe minute fpaces, the fiery mat-
ter there expelled, in the inftant of the
union of the grofs parts, extends the ne-
ceffary ignition through the neighbouring
atmofpheres, and thus a mixture of empy-
real and rare inflammable air, by the mo-
mentary agency of a flint-fpark, is rapidly
expended in the formation of water and
the emiffion of a denfe fiery fluid.

As the adventitious fire requifite for ex-
citing the combuftion, muft have denfity
exceeding that of the atmofpheres in their
interior denfeft parts, it is fcarcely to be
doubted that the greateft denfity in the at-
mofpheres is almoft equal to that of the
fiery fluid iffuing from a red-hot mafs of
iron or of earth; for any incombuftible bo-
dy lefs heated, will not excite combuftion
in the mixture of inflammable and empy-
real air. In this view of the fubject, the
quantity of fiery matter engaged in the at-
mofpheres, appears adequate to the expe-
rienced elafticity of thefe aeriform fluids,
and to all the heat and flame of their com-
buftion.

As

As the diftances of the grofs parts of a mixture of empyreal and inflammable air, and the depth and denfity of their atmof-pheres, are encreafed by heating the mix-ture gradually, in veffels which do not ef-fectually prevent the expanfion of it, the ignition of the veffels to rednefs, or to any degree hitherto experienced, is found infuf-ficient for the inflammation of the mix-ture; for the obvious reafon of the denfer or deeper atmofpheres: and on the confi-deration of all thefe particulars, I fhould expect to find a greater degree of ignition, or a larger fpark, whether of the electric fluid, or from a burning body, neceffary to-wards the accenfion of inflammable with empyreal air, when by averting the preffure of the aerial atmofphere, we fuffer the mixed airs to expand confiderably, than the fame mixture would require in the ordinary ftate of denfity.

To avoid the tedious enumeration and dif-cuffion of phenomena of this kind, I would offer this general rule concerning them: The ignition neceffary towards the ac-

cenfion of inflammable air or vapour, in empyreal air, is directly as the denfity of the repellent atmofpheres, and inverfely as the attractions of the gravitating parts to each other, for the reafons abovementioned.

In the mixture of inflammable with empyreal air, which do not in the leaft affect each other, but remain unaltered for any length of time, we fee nothing like aggregation to refift the union of their grofs attractive parts; and we perceive that the powers which impede their union, are totally different from thofe by which the grofs parts are aggregated into folid bodies. We muft therefore refufe our affent to the Chemifts who fay that the ufe of ignition in exciting combuftion, is to weaken the aggregation of the combuftible fubftance.

That aggregation retards the progrefs of combuftion, is not to be difputed; but to fhew why a confiftent fubftance, fuch as refin or charcoal, may perfift in contact with empyreal air, without combuftion; and why due ignition caufes the inflam-

mation

mation of it, I would fay firft, in confor-
mity with all the foregoing notions, that
phlogiftic bodies, whether fluid like oil, or
folid like charcoal or refin, contain the matter
ter of fire in a fixed ftate, and in great
quantity; fecondly, that although it is
thus fixed by prevalent attractive forces, it
ftill repels the like matter of fire appertain-
ing to the empyreal air; becaufe this na-
tural power exifts, as well when it is coun-
teracted and fubdued, as when it acts unre-
ftrained; thirdly, that the grofs parts of
empyreal air are prevented from uniting
with thofe of charcoal, oil or refin, by their
refpective charges or portions of the matter
of fire; and laftly, that the effect of ig-
nition is, in regard to the commencement
of the combuftion, to break and blend the
charges of fiery matter which impede the
union of the grofs particles, as well as to
weaken the aggregation of the confiftent
fubftances. All this is applicable, in refpect
to the ignition of nitre with combuftible
bodies, and the ignition of fulminating
powder, fulminating gold, and other ful-
minating compofitions, which require to

be

be heated to a certain degree, before they enter into combuftion.

When we inflame a combuftible elaftic fluid or vapour, contained in a veffel, and meeting the open air in a narrow aperture, the progrefs or velocity of the combuftion is as the area of the aperture; becaufe the empyreal part of the atmofpheric air is applied in fmall portions, fucceeding each other, but interrupted in the fucceffion by the fixable air or water newly formed. For the fame reafon the combuftion of any aggregate is, in velocity, as the furface prefented to air is, in extent; and as the retardation of combuftion is not as the hardnefs of the combuftible body, the aggregation is only a fecondary impediment.

After adopting thefe notions of the agency of ignition, and of the caufes by which combuftion is retarded, we fhall find no difdifficulty in anfwering the following queftions:

Y 4   Why

Why do light inflammable air and em-
pyreal air, mixed in due proportions, defla-
grate totally, and to our fenfe inftantane-
oufly, on the application of a fpark or of a
body ignited to rednefs; but not without
this ignition? And why are the emiffion
of fire and the formation of water fimulta-
neous?

Why does a mixture of heavy inflam-
mable air and empyreal air, require the like
ignition for its afcenfion, and then defla-
grate totally and inftantly, and yield fixable
air as well as water and fire?

Why does any exceffive quantity of em-
pyreal or of inflammable air, beyond the
determinate proportions in which their
grofs parts can combine, remain elaftic and
unaltered, or not altered in any confide-
rable part of it, after the combuftion?

Why do the nitrous alkaline and fulphu-
reous particles of fulminating powder, re-
main quiefcent in the contact of them,
until fome part of the powder is duly ig-
nited;

nited; and why does the combuftion exci-
ted by fuch ignition, proceed flowly through
mixture? Why do the fame materials,
when they are more perfectly mixed by
fufion, deflagrate with inftantaneous and
dreadful explofion, in the inftant of the
contact of a fpark with the melted mafs?
And why does this mafs, when cooled and
concreted, deflagrate by the contact of a
fpark, rapidly indeed, but not fo inftanta-
neoufly as the melted mixture.

Why does fulminating gold, which con-
tains empyreal air, and the phlogiftic mat-
ter which the volatile alkali introduces,
require ignition for its afcenfion; and why
is the deflagration of it inftantaneous?

Why, in all mixtures of folids, contain-
ing phlogifton and empyreal air; or in
gunpowder, which contains empyreal air
and phlogifton along with the acid principle
of fixable air; the due ignition of any
part is fucceeded by the deflagration of the
whole? And why is the combuftion the
more rapid, as the mixtion and proximity
of

of the foregoing active ingredients, are made to approach nearer to perfection, by mechanical comminution and diſtribution of the ſubjects containing them.

In replying to theſe queſtions, we neceſſarily furniſh anſwers to thouſands that might be propoſed, concerning combuſtions excited by ignition, and regulated by wicks or other means, or accelerated by arts that ſpeed the influx of empyreal air.

In the ignitions that are neceſſary for the accenſion of different bodies, we obſerve many gradations, from that which iron demands, down to the weakeſt, which is ſufficient for exciting combuſtion in phoſphorus of Kunkel, and which, in fair trials of dry and comminuted phoſphorus, ſcarcely exceeds 60 degrees of Farenheit. But in theſe gradations, we diſcover nothing but what is referable either to the elective attractions of empyreal air and phlogiſton to other groſs bodies and to each other; or to the aggregation of the combuſtible ſubſtances; or finally to the incapacity of fire

to

to blend the atmofpheres and charges already defcribed, unlefs it equals or exceeds them in their greateft denfity.

With regard to the combuftions which commence in the coldeft air, and without the aid of adventitious fire, we need now fay nothing more than that the pyrophori are compounds, which by reafon of their extreme fponginefs, prefent furfaces of the greateft extent, to the empyreal air of the atmofphere, and at thefe furfaces expofe to it, in the fame inftant, the two kinds of matter, namely phlogifton and our acid principle, that attract it with the greateft forces; and that the fum of thefe forces exerted in fuch favourable circumftances, is fufficient to overpower the refiftance of the atmofpheres, and to expel them along with the proper fiery matter of the pyrophori.

In accounting for the fpontaneous accenfion of certain mixtures, fuch as that of black wad and linfeed oil, we are to advert firft to the elective attractions of the em-
<div align="right">pyreal</div>

pyreal air, which one of the ingredients al-
ways fupplies; next, to the phlogiftic and
acid matter prefented by the other ingre-
dient; and laftly to the prevalence of the
attractive forces which tend to the for-
mation of water and fixable air and to the
exclufion of the matter of fire.

In thefe curfory interpretations, I have
purpofely avoided the electrical phenomena;
not becaufe they fhew any thing repugnant
to thefe notions; nor becaufe they afford
no fimilitudes of the repellent atmofpheres,
or of the defcribed condition of the mat-
ter of fire on the furfaces of bodies, or of
the agency of air; nor in confideration of
any ftrong doubt arifing in my mind, con-
cerning the identity of the *matter* of fire
and the *pure* electrical fluid; but for this
reafon, that the electrical phenomena are
intricate in themfelves, and unfit for the
explanation of others. The fame mo-
tives have diffuaded me from the intro-
duction of the phenomena of heat and
combuftion, producible by friction and
percuffion.

S E C-

SECTION XXIV.

Of Light.

IN attempting a concife and general exposition of the phenomena which depend on the agency of the matter of fire, I have found it expedient to advert firft to thofe which fall within the chemical department of Natural Philofophy, and to referve the confideration of Light for this place.

Nothing is more evident than that the fire emitted, during the deflagration of bodies, is a caufe of illumination, and that wherever illumination fubfifts, there is matter in motion. But philofophers do not agree in their opinions of the kind of motion and of the nature of the matter itfelf.

To exhibit, in a few words, the fallacy of fome recent doctrines concerning the

mat-

matter of fire and light, and at the fame time to remove the chief objections which have prevailed with many, as they formerly did in my mind, againſt the Newtonian Theory of Light, the following obſervations ſeem to be ſufficient;

In the fiery fluid which is expelled in the manner already deſcribed, during the ſolution or combination of divers bodies; or which is emitted from heated bodies, in conſequence of its tendency to equable diffuſion; and of the prevalent forces with which the groſs parts of ſuch bodies tend to reſume their former aggregation; we find every degree of denſity or heat, from that which correſponds with 540 degrees, at which lead may be melted, down to that of 60 in Fatenheit's ſcale. All this occurs in proceſſes and ſubjects different from thoſe of combuſtion ; and therefore a great variety, as well as a great number of inſtances can be produced; to ſhew that the fiery fluid may flow from bodies, with the ſmaller or the greater of theſe denſities, without exciting any ſenſible illumination, or giving light.

From

From another train of obfervations we learn, that light may be produced by the emitted fire, in every ftate of denfity, from that which we call temperate, to that of the moft brilliant combuftions. For light is produced, not only by the vivid defla-gration of zinc, iron, or coke, or during the languid combuftion of fulphur ; but is alfo fenfibly propelled during the flow ab-forption of empyreal air by cold phofpho-rus, and the indifputable emiffion of fuc-ceffive portions of the matter of fire.

The legitimate inference from thefe phe-nomena is, not that the matter of light dif-fers from that of fire, but that *Fire* fubfifts by the proximity, and *Light* by the rapid projectile motion of parts of the fame kind of matter : For the latter inference agrees with all the phenomena, whilft the former is repugnant to our experience of the effects of light concentrated by reflection or re-fraction.

In *Fire*, there is always a motion of the parts, by reafon of their tendency to re-

cede

cede from each other, and of their attrac-
tions to bodies; but it may fubfift by the
denfity without the motion; whilft light
fubfifts by the projectile motion, in every
denfity or diffufion of the luminous fluid.

When we confider that the elafticity of
aeriform fluids, is owing to the matter of
fire; that a cannon-ball is propelled only
by the excefs of the repellent powers of
parts of this matter, above the forces with
which they are attracted by the grofs parts
of gunpowder, or of the airs emitted during
the deflagration of it; that the velocity of
the ball is incomparably lefs than it would
be if it were fhot through an unrefifting
medium; and that even this latter velocity
would be an inadequate reprefentation of
that, with which the parts of the fiery
matter are fhot forth, in the firft inftant of
their liberation from the combuftible body
which held them clofely approximated;
we find the natural powers already defcri-
bed, fufficient in themfelves, for the pro-
jection of thefe parts, with all the velocity

ex-

experienced in the light of flaming bodies on earth, and to every diftance at which it has been perceived.

In regard to the light of the fun, we need imagine nothing more than the fame matter propelled by the fame powers, in greater quantity, and with greater vigour, by reafon perhaps of a purer and denfer atmofphere, and of a greater proportion of the fiery matter relatively to the reft of his fubftance; for in fuch circumftances we produce the moft rapid and luminous combuftions of folid bodies.

In combuftions effected by the incumbent air, this acts on the combuftible bodies in fucceffive portions, and the matter of light is neceffarily projected in like manner, and the parts which fucceed each other in the fame lines, anfwer to Newton's definition of a ray of light.

In the rays of light then, we find matter and motion enough to produce all the

Z effects

effects hitherto noticed, on chemical fub-
ftances, on water, on vegetables, and on
folar phofphori.

Having thus traced the matter of fire in
various ftates, to that condition in which it
coincides with Newton's character of light,
it is unneceffary to infift on the conformity
of the foregoing notions with the optical
phenomena, further than by remarking that
the ethereal medium which affects the fur-
faces of bodies, and to which he afcribes
divers effects, does not appear to confift of
any other than the matter of fire, which
by the fame powers that form atmofpheres
around the folitary grofs parts, muft neceffa-
rily form a denfe elaftic medium on the fur-
ces of their aggregates.

As I have frequently diftinguifhed the
parts of other matter from thofe of fire, by
the term *gravitating parts*, it is neceffary
now to fay, that this mode of expreffion,
is not intended to convey an opinion that
the matter which attracts fo many bodies,
<div align="right">does</div>

does not gravitate to the affemblage of them in our earth, but relates to the *fenfible* gravitation of any quantity that we can fubmit to mechanical trials.

SECTION XXV.

Of fermentation, putrefaction, and respiration.

THE phenomena of fermentation, putrefaction, and respiration, agree so strictly with these notions, and are so easily explained by them, that it is altogether unnecessary, in the following sketch, to notice any other than the objects of the greatest importance.

Mr. Cavendish has shewn, that from one hundred parts of sugar duly fermented, fifty-seven are expelled in the form of fixable air. Therefore, unless we suppose that the water used in the process is decomposed, which is by no means probable, the conversion of sugar into spirit is effected by the abstraction of 38 parts, or thereabouts, of empyreal air and 19 of acid matter; and the spirit consists of about 43 of phlo-

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giftic

giftic and acid matter, combined with fome
of the water employed in the procefs : For
we need not, at prefent, regard the fmall
quantity of precipitated earthy matter.
The fpirit then confifts of the vegetable
acid principle more fully faturated with
phlogifton than it is in fugar, and affociated
with water; and the fuperfluous acid mat-
ter together with the empyreal air, enga-
ging a part of the matter of fire that is li-
berated in confequence of thefe new unions
by the mediation of water, efcape by reafon
of the repellent atmofpheres.

This perfectly correfponds with the na-
ture of the products of fugar by ignition ;
for the fixable air which it yields abun-
dantly, fhews that empyreal air enters into
its compofition ; the inflammable air,
oil, and combuftible coal, which it affords,
fhew all the acid matter and phlogifton that
we find in the fpirit; and in the earthy
part of the charred coal of fugar, we ac-
count for that which fubfides in the fer-
mented liquor, or may be abftracted in dif-
tillation.

The

The fubfidence of earthy matter from a limpid folution of fugar, during the fermentation and new combinations, is eafily accounted for in this confideration; that the empyreal air, which is the caufe of the menftrual power of acids, is carried off along with that part of the acid principle that is not engaged with phlogifton to form fpirit; and that the refiduary fpirit, or any faccharine acid that may remain, cannot hold the earth in folution.

Thefe general inferences are true, altho' the fixable air might have been over-rated, by its being meafured along with the watery vapour which it always carries with it, in thefe circumftances.

This reprefentation alfo correfponds with every thing that is worth notice in the preparation and properties of the acid of fugar; for it is prepared in nitrous acid by the abftraction of fome of its phlogifton, and by fupplying empyreal air to the refiduary matter; and the acid of fugar thus conftituted, cannot be made

to

to ferment and yield ardent fpirit, or any fuch quantity of oil or inflammable air, as may be had from the fugar.

The changes producible by fermentation, in farinaceous fubftances, admit of the fame concife explanation in regard to the acid and empyreal air extricated, the retention of all the phlogifton with the refiduary acid matter in the form of fpirit, and the feculent fubfidence confifting of earthy, faline, and infoluble fatty matter, or of farina which has eluded the decompofition.

A fpirituous liquor, confifting of water and acid matter faturated with phlogifton, contains every principle of acetous acid, except the empyreal air. But this is ftrongly attracted by the acid and phlogiftic matter of the fpirit; and therefore by due expofure to atmofpheric air or pure empyreal air, or even to that which is held in nitrous acid, the fpirituous liquor becomes vinegar, either in the acetous fermentation, or in chemical proceffes, fuch as the ingenious and indefatigable *Scheele* has defcribed.

And

And now the reafon is obvious, why vine-
gar may be made of wine, but no wine of
vinegar, by ordinary fermentation; and the
anfwer is eafy, in regard to every queftion
that has ever been agitated on the fubject
of fermentation, unlefs we except that
concerning the agency of yeaft and leaven.

Yeaft is not always neceffary to the vi-
nous fermentation; but when it is ufed to
infure it, under unfavourable circumftances
of cold air, imperfect folution of farina-
ceous matter, or vicidity of the fermentable
liquor, it feems to ferve only, like the par-
tial ignition formerly defcribed, to give in
fome part of the mafs, a certain prepon-
derance of the forces which tend to the
new combinations, over thofe of the che-
mical attractions, gravitation, aggregation,
and *inertia*, which confpire to maintain
the fermentable liquor unaltered. The
matter which gives this preponderance,
might eafily be afcertained by an accurate
analyfis of yeaft. It feems to be acetous
acid, already formed, and engaged in mag-
nefian earth and oil, beyond the quantity
necessary

neceffary for the faturation of the former: for this correfponds with an imperfect ana- lyfis of yeaft, that I made many years ago; and with the common practice of accele- rating the fermentation of ales, by foured ale; and with the ufe of four bread or leaven in exciting a fpeedy fermentation in dough; and with the effect of four ftalks or hufks of grapes, or foured cafks, in exciting the acetous fermentation fpeedily, in a vinous liquor; and with the uncommon efficacy which I have experien- ced of bread foaked in concentrated vinegar, in expediting the converfion of wine to vinegar; the change induced in the vicinity of a fmall piece of it, being found, in due expofure to the common air, to ex- tend quickly through the whole of the vi- nous liquor.

The phenomena of putrefactive fermen- tations vary, with the kinds of matter in the fubjects, with the proportions of thefe, the quantity of water, and the circumftances which contribute to the retention or diffipa- tion of the liberated matter of fire: amongft

Thefe

thefe circumftances we muft rank the partial or free concurrence of the atmofpheric air. But neither the incalefcence, nor the fixable air, or the denfe inflammable air emitted, nor the diffolution of the organifed bodies, nor the wafte of their volatile parts, nor the combuftions and confumptions which happen in fome inftances, fhew any thing that is not eafily deducible from the foregoing notions.

Finally, with the proceffes, in which fixable air is not only extricated but formed, and in which the matter of fire is at the fame time liberated, I muft rank that of refpiration; in which the thin *reticular* bronchial membrane, rather promotes the agency of the air on the circulating blood, than prevents it by interceding them.

As all the faccharine, farinaceous, herbaceous, and oily vegetable fubftances, that are ufed as food, and all the efculent animal fubftances alfo, abound with the fame acid and phlogiftic principles that are contained in our ethereal oil and in-

<div align="right">flammable</div>

flammable air of acetous acid and ardent
fpirits; as thefe principles form a confi-
derable part of the blood, and are well
known to attract empyreal air, even when
they are diffufed in water and combined
with other matter, as it happens in the vi-
nous and acetous fermentations, in putre-
factions, and in other proceffes analagous
to thefe; the aptitude of the blood to act
on empyreal air, might be argued a priori,
tho' not fo fairly proved as it has been by
the experiments firft made by Dr. Prieftley,
and afterwards profecuted by the Abbe Fon-
tana and Mr. Lavoifier.

An experiment which I made in May
1785, in my public courfe of Chemift-
ry, and which I afterwards repeated,
with the precaution of expiring all the air
that I could from my lungs, and of breathing
for a while fuch air as I intended to try,
feems to have cleared away all the doubts
that attended this fubject. It confifted in
breathing two gallon meafures of empyreal
air from nitre, in a glafs veffel, poifed and
moveable in lime-water, fo that the air
within

within was always equally compreffed by the atmofphere, under every diminution of bulk by infpiration, and the refpiration was made without labour.

The lime water, in which the veffel floated, was further impregnated with perfect lime, and this liquor was conftantly dafhed and fprinkled through the refpired air, by the hand of an affiftant, to accelerate the abforption of the fixable air from the refiduary elaftic fluid; and thus I was enabled to continue the refpiration much longer, wirhout interruption, or preparing my lungs anew, than I could otherwife have done. Notwithftanding all this, I could not continue the refpiration to the total confumption of the empyreal air, but was obliged to defift at intervals, and to return repeatedly to the refpiration, with my lungs prepared as formerly, after the whole of the fixable air had been abforbed by the lime liquor from the remaining empyreal air.

The decreafe in the bulk of the refpired air, not at all correfponding with the real

con-

consumption of empyreal air, and the quan- tity of phlogisticated air greatly exceeding that which might have eluded my previous trials of the empyreal air, both contributed to shew that some phlogistic air was pro- duced or detached during the procefs : And now that Mr. Cavendish's experiments prove that the phlogistic air could not have been formed of the empyreal air, I do not hesitate in concluding, that the former was expelled from the lungs during the respi- ration, along with the matter which con- tributed to the formation of the fixable air. It therefore is not to be regarded in the present consideration of the expenditure of the empyreal air.

As the pursuit of this last was my chief purpose, and I have not room now for a circumstantial detail of particulars, I shall confine myself to the following report :— After the last respiration, which was main- tained with great difficulty and anxiety, the empyreal air disappeared totally, the residue being mere phlogistic air, and the fixable air was not equal in weight to the expen-

ded

ded empyreal air; therefore one-third of the empyreal air muft have been otherwife engaged.

But from the moft general analogy, and from the quantity of watery vapour that iffues from the lungs at every expiration, whether we breathe empyreal air or atmof-pheric air, we may conclude that whilft about two-thirds of the empyreal air were employed in forming fixable air with the acid principle of the oleaginous part of the blood, the remainder of the empyreal air was expended in the formation of water, or perhaps, by fome fmall part of it, in entering the blood : and fince a great quan-tity of the matter of fire is detached, in every procefs, whether of the mixture of elaftic fluids, or putrefaction, or fermenta-tion, or of the folutions of vegetable or animal fubftances in nitrous acid, or of combuftion; whenever empyreal air is ex-pended in the formation of fixable air or water, and efpecially when both are com-pofed at the fame time; I fee no reafon to doubt of the truth of Dr. Crawford's opi-nion,

nion, that animal heat is generated in the
lungs, and diftributed from thence to the
reft of the body by the circulating blood :
And thus the phenomena of refpiration
agree perfectly with the foregoing notions
of matter.

F I N I S.

CORRECTIONS;